POWER

Vol. 40 NEW YORK, SEPTEMBER 22, 1914 No. 12

Candid Chats

The Job That Wanted A Man--A True Story

"Hello, Mr. Veers? This is Mr. Ponce of the Ponce Steel Co. Say, Veers, we need a chief engineer for our Du Twain Works. You've been an assistant there; you know the plant. Would you like to take the job?"

"Thanks, Mr. Ponce; but I've a good place here. I greatly appreciate your thoughtfulness for calling me up, though."

"Job pays $1800 a year, Veers, and there's two weeks' vacation, with pay in advance. We'll do better. All depends on the quality of the man. Can't consider it, eh? Well, can you recommend a man that's capable of the job? You know a lot of engineers."

"Don't know of a good man that's idle, one that I could send you, Mr. Ponce, but I'll see what I can do. Don't mention it. Good-by."

Veers was silent for a full three minutes, then lifting his head with a jerk, exclaimed:

"Beats the devil, doesn't it? I know at least three hundred men in this city—all fine chaps, personally—that'd jump for that job like a hungry dog for a bone, but I dare not send one to the place!"

"*Dare* not send one? Why?" I asked in amazement.

"Y'see, it's an alternating-current job—2400 volts to the board and transformers, then 240 to the motors in the scattered buildings. It's an up-to-the-minute plant; runs day and night. A moment's interruption of service would throw the management into nine cat-fits. They're exacting, but as square as a Quaker. They're willing to pay for the goods, but they *want* the goods.

"Our boys in this town are not up on the A. C. stuff. They'd fall as sure's my name is Veers. Then I'd get in wrong. Too bad! But it's mostly their own fault. Goodness knows, the sources from which to learn about running an A. C. plant are many.

"I help these boys all I can—always put better jobs in their way—but some other fellow's going to get this one."

Virginian Power Co.'s New Steam-Turbine Plant

By Warren O. Rogers

SYNOPSIS—The present 20,600-kv.a. output of the plant will be consumed by coal-mining operations for cutting, hauling, hoisting, ventilating and pumping. The plant is constructed on the unit plan, each generator unit having its own boilers; combinations can be made, however. Coal is delivered to the boiler-house bunker by a skip hoisting system and cable-drawn cars, which automatically unload into the bunkers. Coal is discharged from the bunker to the mechanical stokers of the twelve 600-hp. water-tube boilers.

The project of generating electrical energy at a central power plant to be used for operating the hundreds of coal mines of the Kanawha and New River districts within a radius of 50 miles has just been consummated by C. O. Lenz, of New York, who designed and constructed the new 20,600-kv.a. capacity steam-turbine power plant of the Virginian Power Co., at Cabin Creek Junction, W. Va.

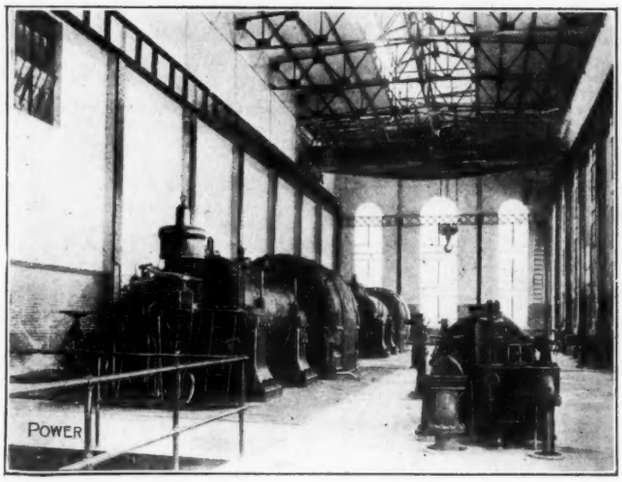


Fig. 2. Turbine Room of the Virginian Power Co., Cabin Creek Junction, W. Va.

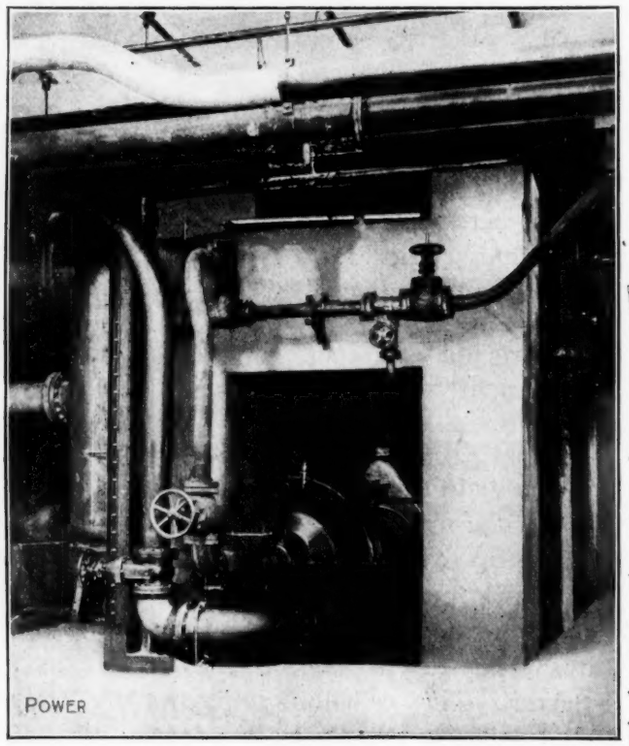
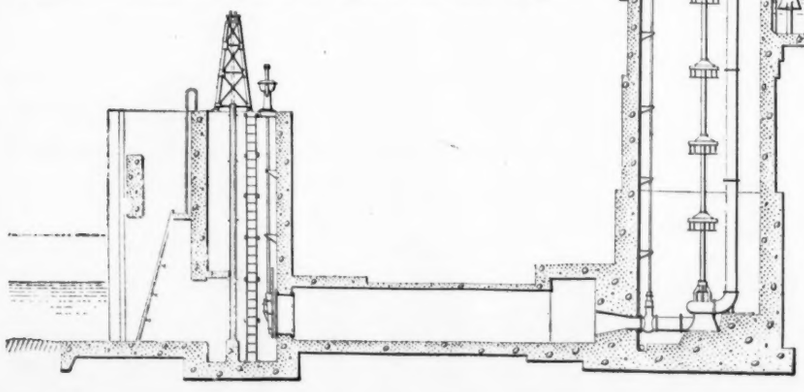


Fig. 1. Condenser and Turbine Driving Pump

The plant is built on an 11-acre plot of land, owned by the company, and is on the west bank of the Great Kanawha River, and on the main line of the Chesapeake & Ohio R.R., which affords delivery of coal from the Cabin Creek district. An idea of the number of mines in the 50-mile radius from the power house is had when it is known that on the Cabin



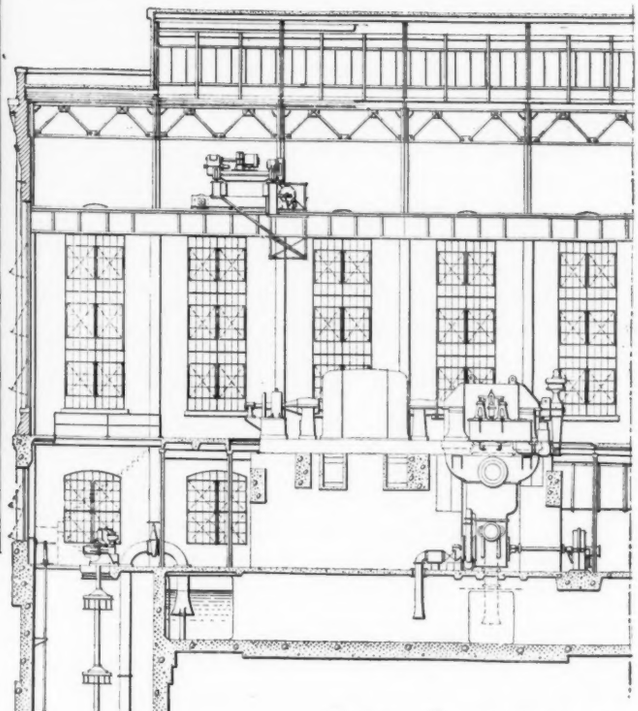


Fig. 3. Elevation of the

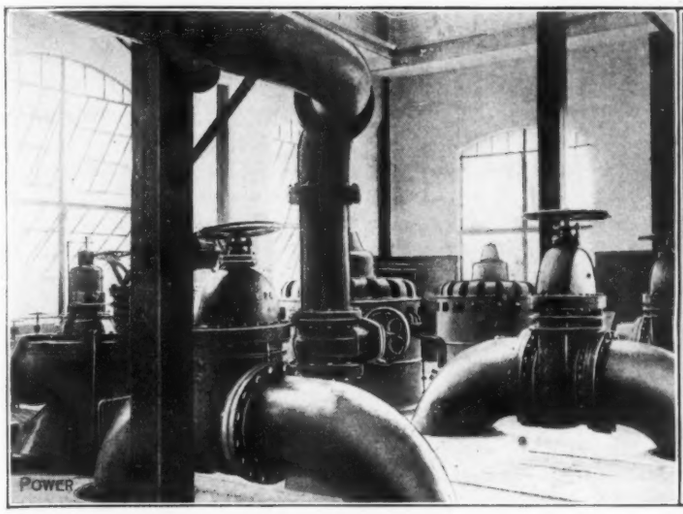


FIG. 4. A VIEW OF THE VERTICAL TURBINE AND MOTOR-DRIVEN PUMPS

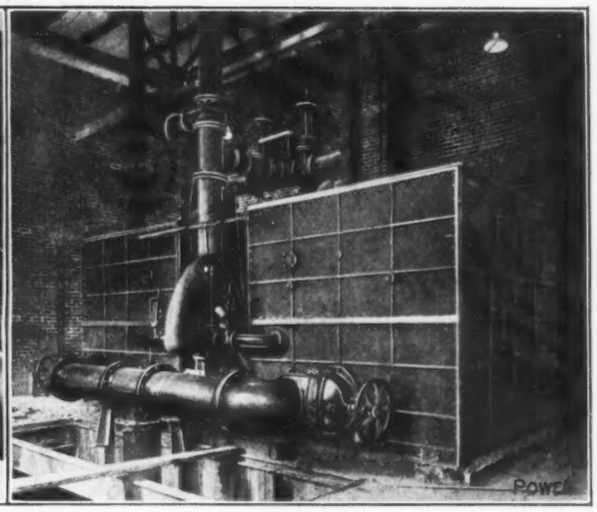


FIG. 5. THE TWO 10,000-HP. OPEN FEED-WATER HEATERS

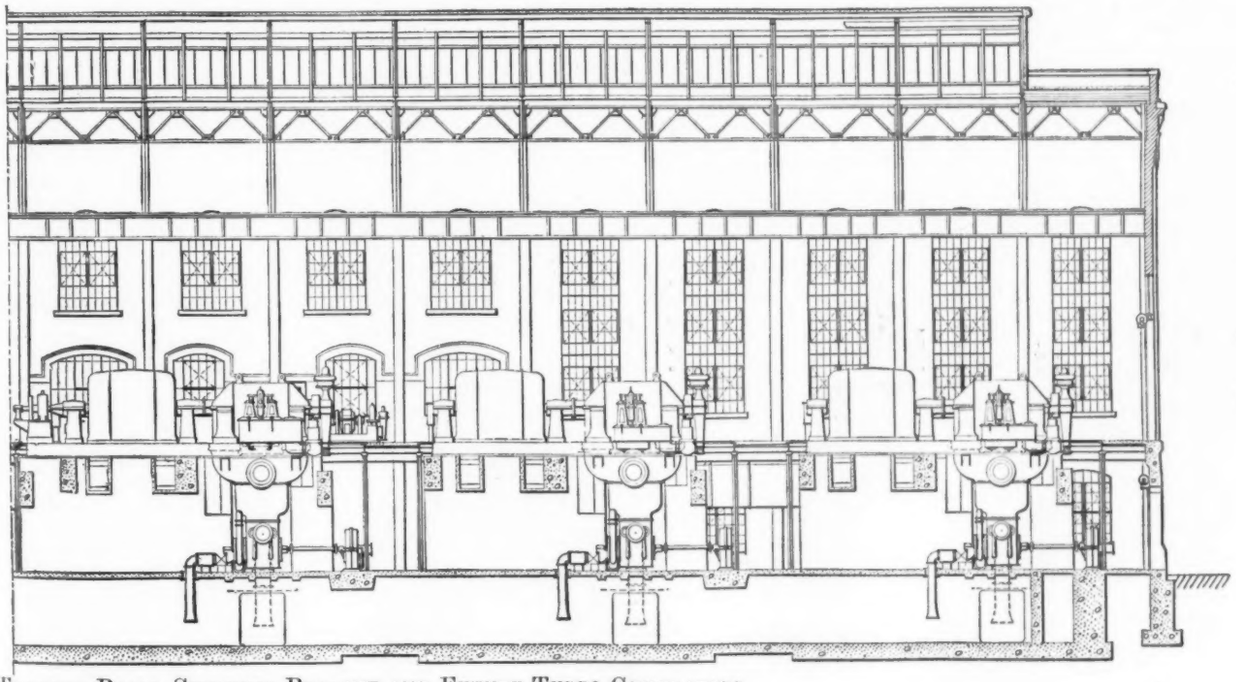
Creek branch of the railroad there are 52 mines in a distance of 50 miles. The mines which the plant will serve operate on a 24-hr. basis and a load factor of 35 per cent. is expected at the power plant.

BUILDING

The turbine room is 237 ft. long and 50 ft. wide. The two boiler rooms are in wings built at right angles to the turbine room, which leaves an open court between them. The boiler rooms are each 140 ft. long by 92 ft. wide.

grade, a basement has been eliminated. The main operating floors of the boiler and turbine rooms are 17 ft. 2 in. above the ground floor, which permits of natural light to all parts of the building, also free ventilation.

The roof is concrete slabs reinforced with "Hyrib" and pitched and valleyed to low points for drainage. To insure tightness, four-ply "Hydrex" roofing is used for a roof covering, bolted slag being spread over the roof covering to prevent the compound from flowing. All



TURBINE ROOM, SHOWING PRESENT AND FUTURE TURBO-GENERATORS

The superstructure is built on a concrete foundation and base courses. The superstructure is a self-supporting skeleton steel frame encased with brick, which are pilastered at the columns with a cornice of concrete and brick around the building. Both the boiler- and the turbine-room walls are broken by spacious windows, the frames and sashes of which are steel. As the boiler and turbine buildings have a ground floor at 6 in. above floors are steel frames holding reinforced-concrete slabs, and are capable of carrying a gross load of 400 to 600 lb. per sq.ft.

TURBINE ROOM

The present equipment consists of two 10,300-kv.a. double-flow turbo-generators, delivering three-phase, 60-cycle, 6600-volt current when running at 1800 r.p.m.

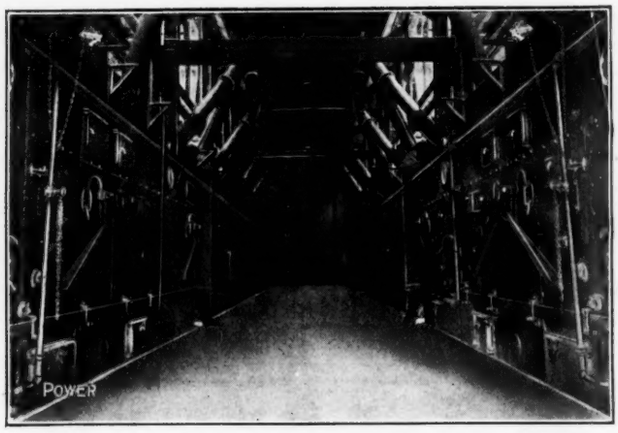


FIG. 6. FIRING AISLE IN NO. 1 BOILER ROOM

Each is equipped with a 90-kw., 125-volt, direct-current, direct-connected exciter. There is also a 100-kw., 125-volt, 2400-r.p.m., single-stage turbine-driven exciter unit as a standby. These are shown in Fig. 2. The two turbo-generators which will be put in when the demand for electrical energy warrants will not have self-contained exciters, there being sufficient direct-current capacity in the three present exciters.

The station can be operated on the unit plan, that is, any one turbine with its boilers, generator and its step-up transformers and feeders independently; interconnections are possible, however.

The main turbine units are connected to a suspended No. 20 Leblanc condenser, the pumps for which are driven by a 250-hp. reëntry steam turbine at 700 r.p.m. These are on the ground floor, as shown in Fig. 1. The condenser is between the turbine foundation columns, with the turbine outside. This allows for a connecting shaft long enough to permit movement of the condenser with temperature changes.

An abundant supply of clean condensing water and boiler feed is obtained from the river. Screens prevent débris entering the pumps. From the intake, the water flows through two 28-in. pipes to a small surge basin, from which the water flows by gravity to the main water-supply pumps. These are in a pit 53 ft. below the pump-room floor, which is on the ground level and at the river end of the turbine building, as shown in Fig. 3, which is an elevation of the present and contemplated turbine room.

There are three main pumping units, Fig. 4. Two are 24-in. vertical shaft pumps, with a capacity of 17,000 gal. per min., running at 385 r.p.m., driven by 320-hp., 440-volt induction motors. The other is an 18-in. pump with a capacity of 8500 gal. per min., at 550 r.p.m, driven by a 165-hp. vertical steam turbine. These pumps discharge into a concrete flume which extends the length of the building under the turbine-room floor, and from

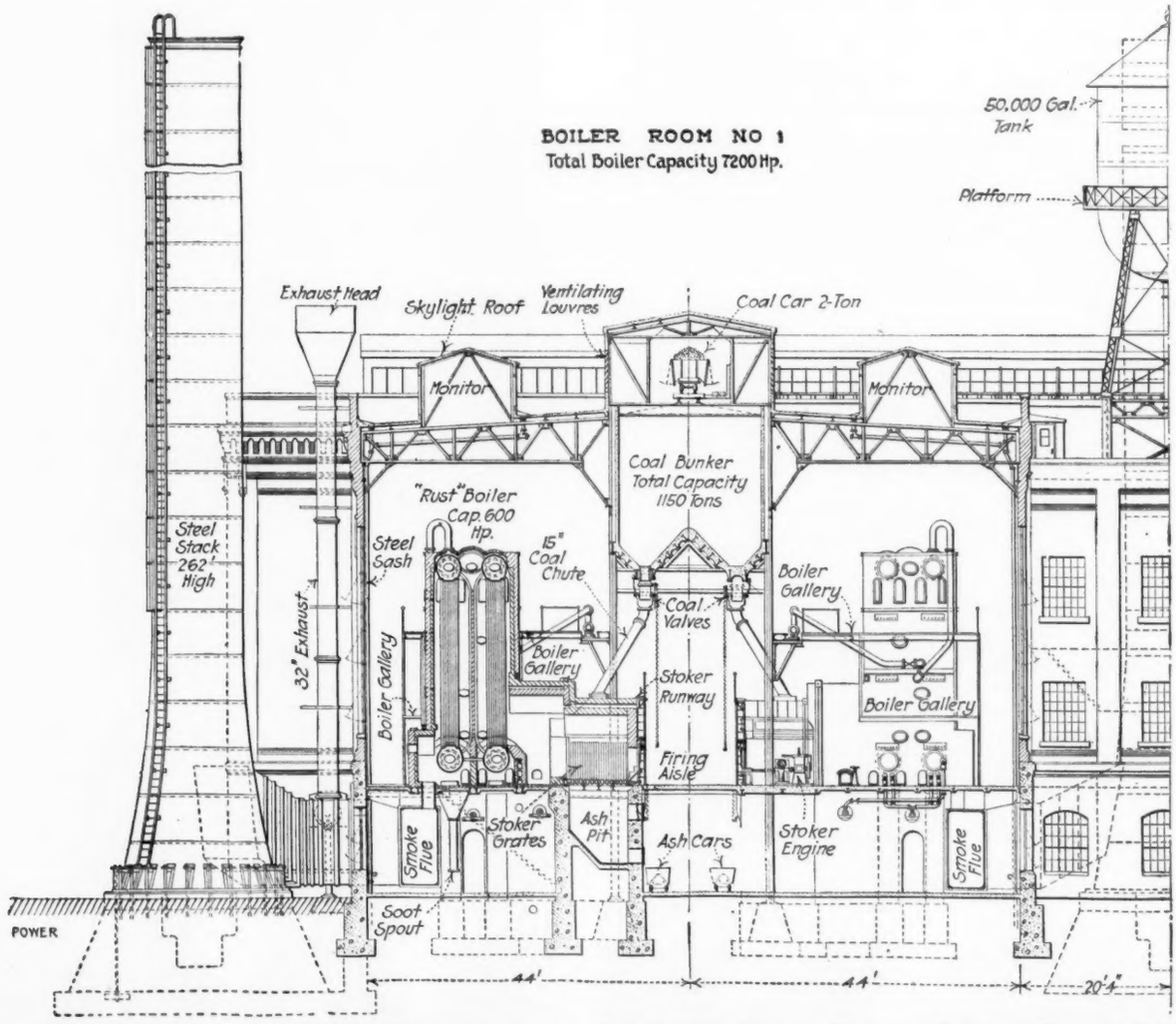


FIG. 7. ELEVATION OF THE TWO BOILER HOUSES, EACH TO CONTAIN TWELVE 600-HP.

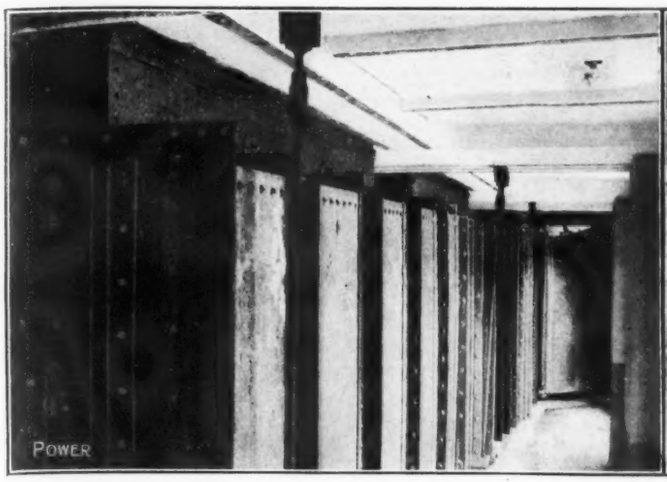


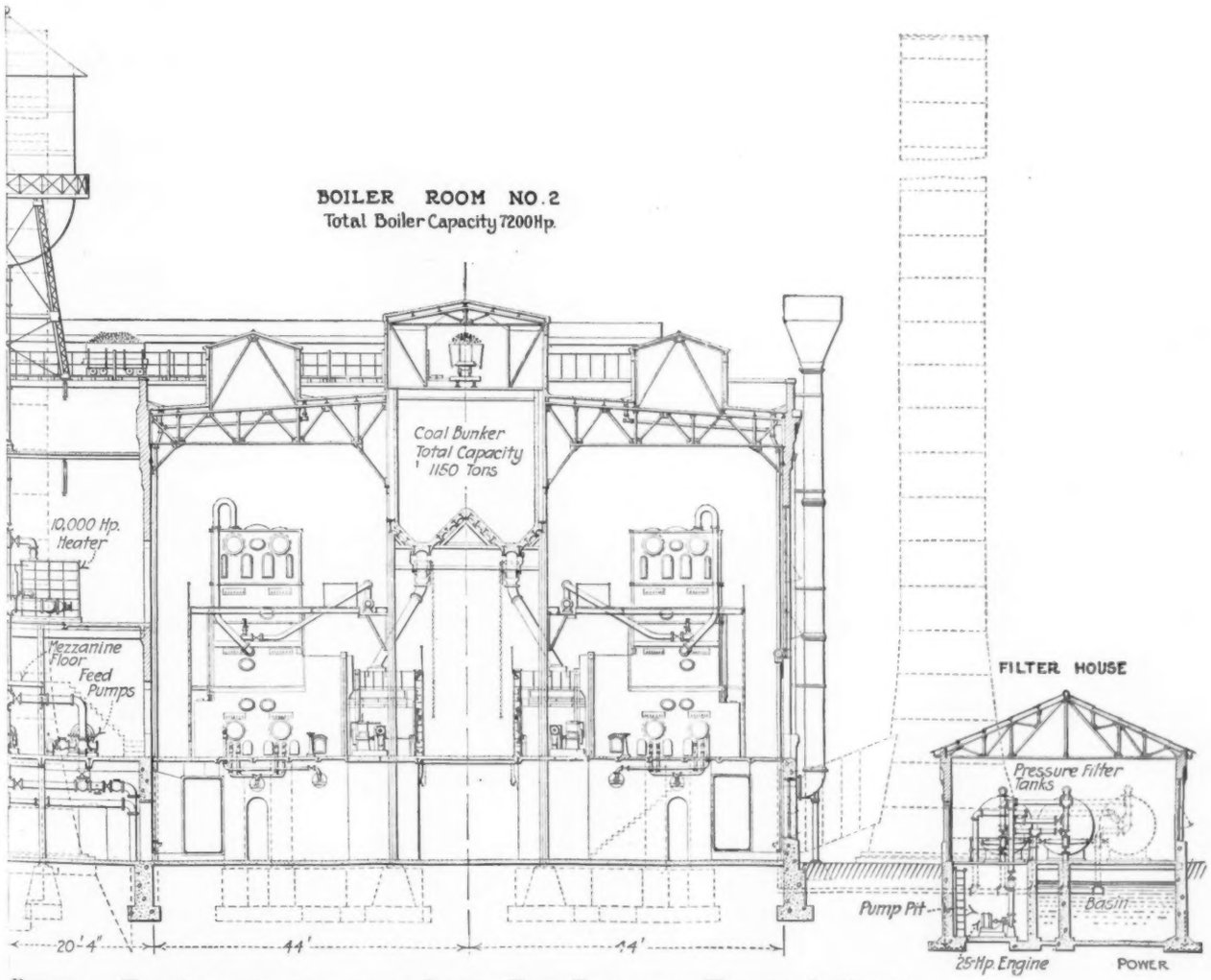
FIG. 8. SMOKE FLUE BELOW THE BOILERS

FIG. 9. SMOKE-FLUE CONNECTION TO THE CHIMNEY

which the injection water is pumped to the condenser.

Alongside of the intake flume is a discharge duct into which the condensers discharge, and which also receives the overflow from the intake flume. The discharge from the condensers flows to a concrete discharge tunnel, which empties into the river just below the intake portal. As the flow of the river carries the water down stream, this does not affect the condensing water temperature.

At the boiler side of the wall dividing the condenser from the ashpit rooms are two double-suction, 6-in. horizontal, centrifugal pumps, each having a capacity of 1200 gal. per min. One is directly connected to a 75-hp., three-phase, 60-cycle, 440-volt induction motor and runs at 1760 r.p.m. The other is driven by a single-stage steam turbine at 1760 r.p.m. These pumps elevate water from the intake tunnel to a 50,000-gal. tank on the roof



BOILERS. THE ARRANGEMENT OF THE BOILER FEED PUMPS AND HEATERS IS SHOWN

FIG. 10. ALLEY BETWEEN THE ASHPITS

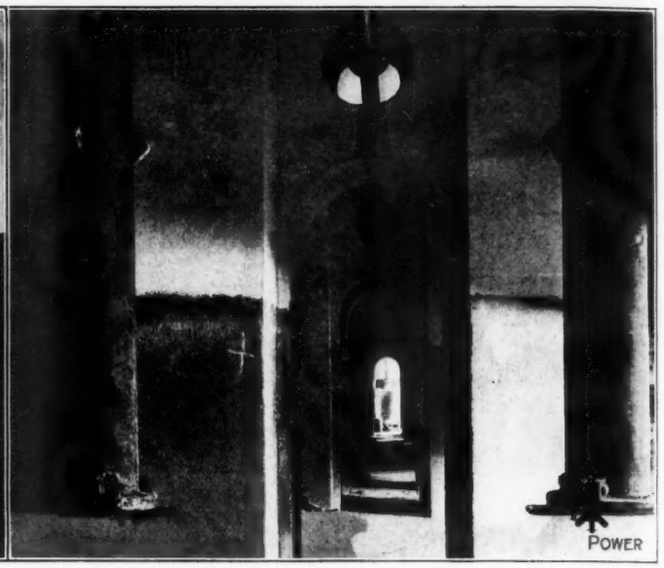


FIG. 11. CINDER CHUTES UNDER THE BOILERS

either directly or by pumping through pressure filters. The filtered water is for boiler feed makeup and general house service.

BOILER FEED PUMPS

The two 10,000-hp. open feed-water heaters and purifiers, Fig. 5, are in a room between the two boiler-room bays. Below, on a level with the boiler-room floor, are two 400-gal. per min. double-suction, triplex, turbine-driven boiler feed pumps. Each runs at 3000 r.p.m. and delivers water to the boilers at 225 lb. pressure; the turbines are of 96 hp. each. This arrangement gives a good head to the feed pumps.

BOILERS

As already stated, the boiler plant, Fig. 6, will be in two separate houses. The one boiler house at present completed contains six batteries of two boilers each. These

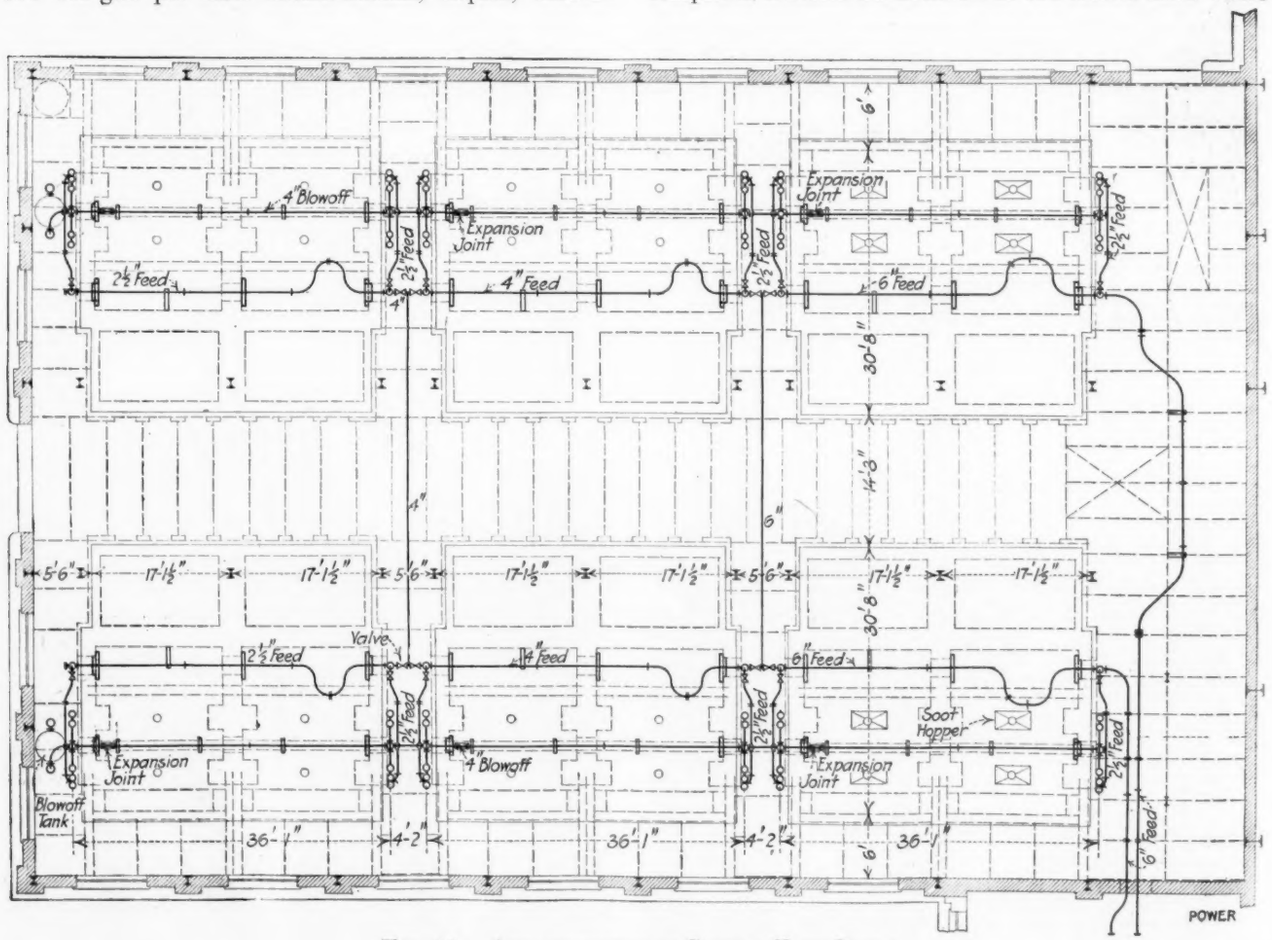


FIG. 12. ARRANGEMENT OF BOILER FEED PIPES

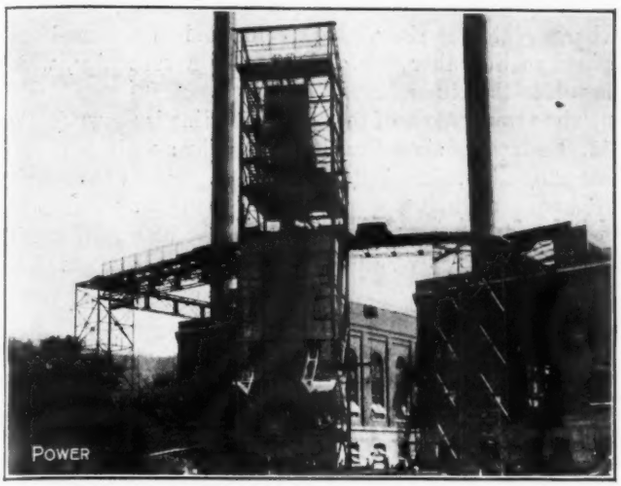


FIG. 13. COAL- AND ASH-HANDLING TOWER AND CABLE-CAR RUNWAY

water-tube boilers are of 600-hp. capacity, or 7200 hp. total. Each boiler has a total effective heating surface of 5882 sq.ft. This boiler capacity gives a ratio to the combined turbine capacity of approximately 1 to 2.9. The boilers have dutch oven furnaces, which are equipped with mechanical stokers, each 8x12 ft., or 96 sq.ft.; this

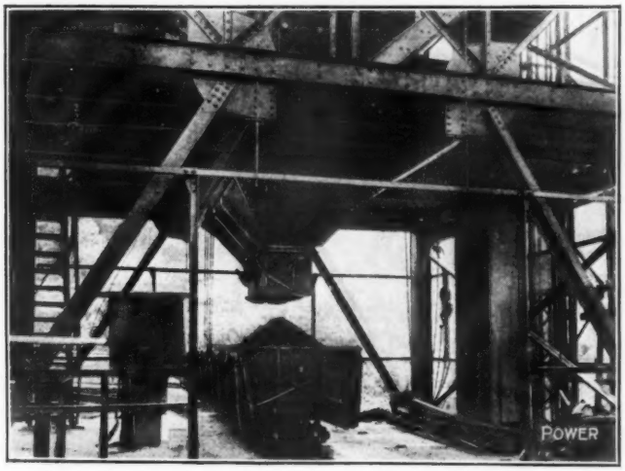


FIG. 14. CABLE CAR, LOADED WITH COAL, ON TRACK SCALE

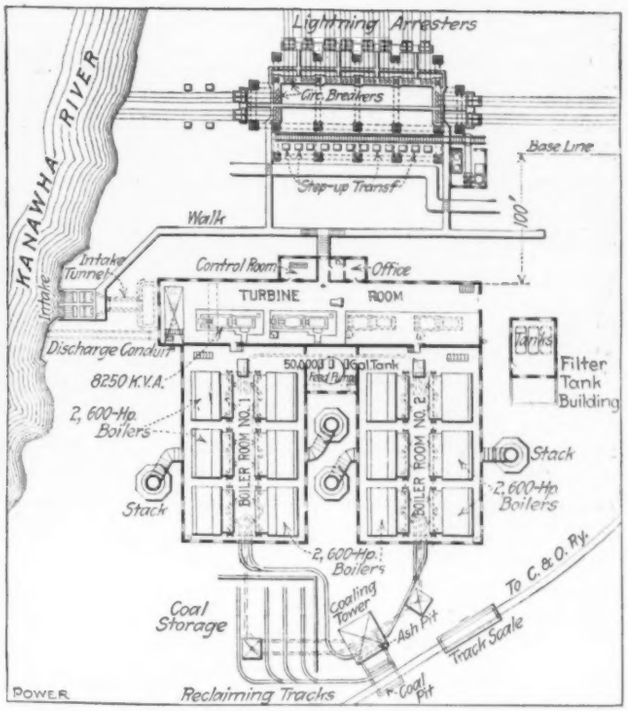


FIG. 15. GENERAL PLAN OF THE POWER-PLANT LAYOUT

with the back plate gives an effective grate area of 120 sq.ft. per boiler, or a ratio of 1 to 5 to the boiler rating. As each boiler has 5882 sq.ft. of heating surface, the ratio of grate surface to heating surface is 1 to 49.

Natural draft is used in the furnaces, with which the furnace and stokers can be forced to 200-per cent. rated capacity for peak loads.

The boiler house is divided into two sections, Fig. 7, a row of six boilers on a side, with a firing aisle between. The boilers have superheaters, which superheat the steam 50 deg. A pressure of 185 lb. is carried.

Each row of six boilers has a self-supported steel stack, brick lined from top to bottom. The stacks are 262 ft. high and have an inside diameter of 11 ft. 4 in., giving 101 sq.ft. of cross-sectional area.

The boilers are connected from the last pass to a lined steel smoke flue, Fig. 8, which is under the rear of the boiler on the ground floor. Midway of the building, the flue goes out through the wall to the stack, Fig. 9. This arrangement eliminates all sharp turns in the passage

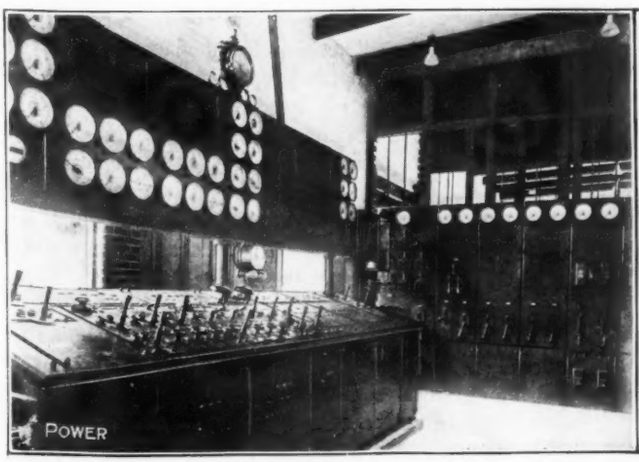


FIG. 16. CONTROL ROOM

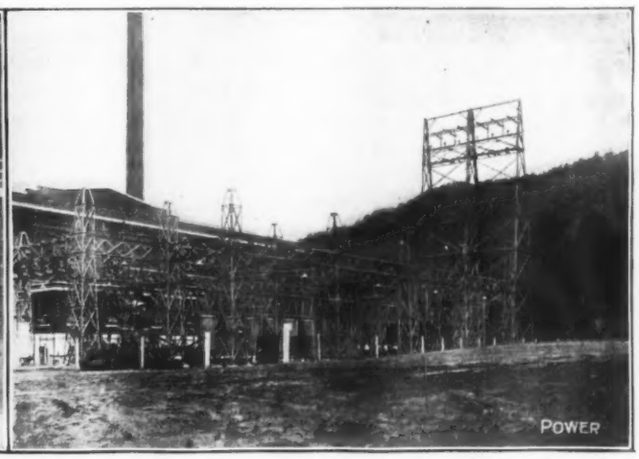


FIG. 17. OUTDOOR TRANSFORMER STATION

of the flue gases to the stack and puts the flue below the boiler room out of the way.

The setting of the boilers is arranged with fire-brick lined ash pits, which are on the ground floor of the boiler house. They are made with a sloping bottom, so that the ashes can be raked out into a one-ton ash car, which runs on tracks in the alley between the two rows of ash bunkers, Fig. 10. The ashes will at first be used for filling in around the plant, but later, when not required for the purpose, will be wheeled to the ash track hopper at the coal and ash elevator out in the yard and elevated by skips to an ash bunker in the tower.

At the back of the boiler ashpits are two cinder bunkers into which the cinder falls in passing through the two passes of the boiler. Each has a sealed discharge chute, which makes cleaning out comparatively simple. The chutes are shown in Fig. 11, which is a view through the alley under the boilers.

At the far end is shown the blowoff tank, which discharges into the river. It is connected to a second tank piped to the other row of boilers by a vent pipe, which is run to the atmosphere.

The arrangement of the boiler feed line is shown in Fig. 12. Each set of six boilers is supplied by a main 6-in. line, reducing at the last boiler to 2½ in. Besides the regular feed connection, a 2½-in. branch pipe is tapped into the main feed line, and is connected to the blowoff line with suitable control valves between. This gives an emergency feed for each boiler. In addition, there are a 4- and a 6-in. line between the two main feed lines, so that any combination can be made to get water to all boilers if either main feed line fails.

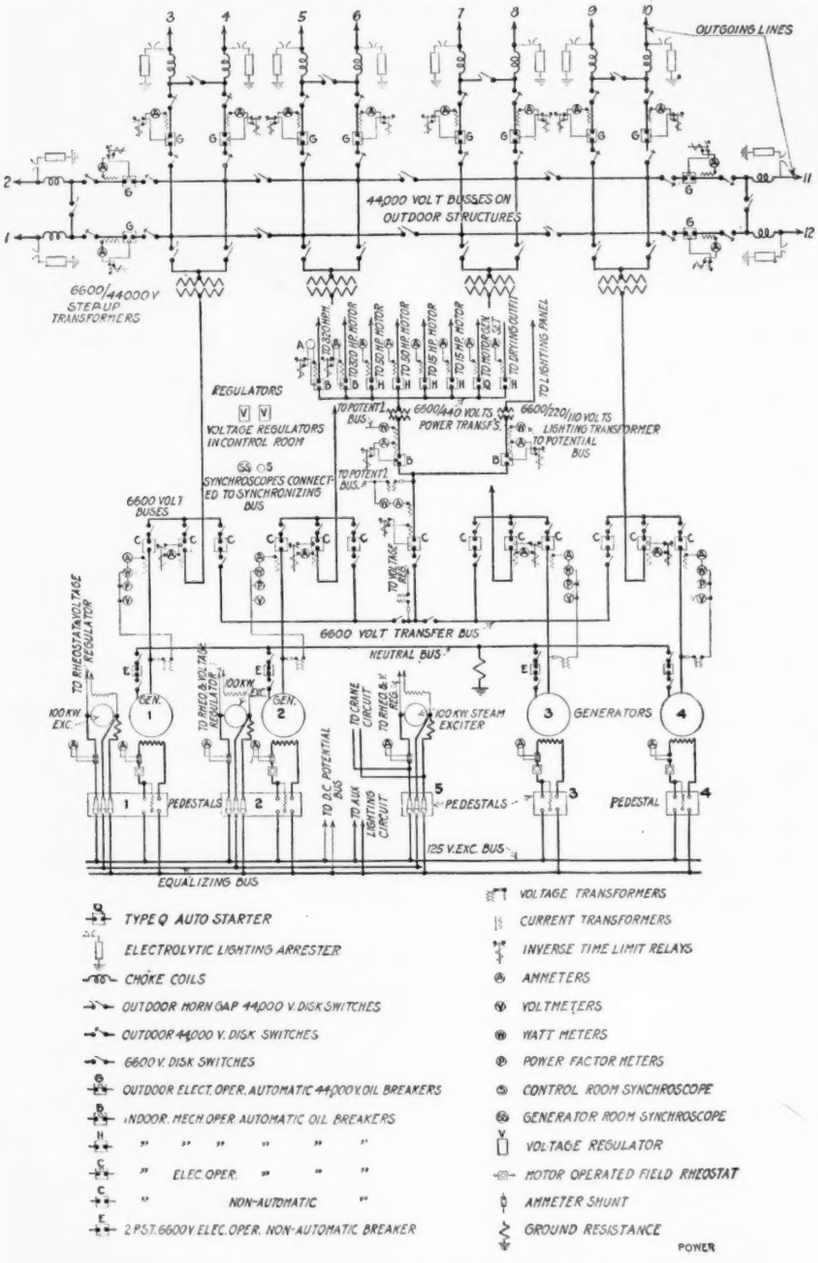


FIG. 18. WIRING DIAGRAM OF THE POWER HOUSE

COAL-HANDLING APPARATUS

Above the boilers and firing aisle in each boiler room is a steel, concrete-lined coal bunker 120 ft. long. It has a capacity of 12 tons per lin.ft., or a total capacity of 1440 tons. All coal is handled by a hoist contained in a structural steel tower, 124 ft. high, Fig. 13. This houses a concrete ash bunker, concrete-lined coal-receiving hopper, crushing rolls and machinery for operating a double skip elevating system. At the bottom of the tower are two concrete receiving hoppers. One is for coal and holds 60 tons. The other is of the same size and is to receive the ashes from the ashpit cars when wheeled from the boiler house.

Coal is switched over the coal hopper and discharged into it. The hoisting skips lower to a point below the discharge spout of the hopper, so that the coal runs into them by gravity, the flow being controlled by an S-gate operated by a lever from the operator's platform. Before the gate opens, however, a movable chute is moved out with the same operation, so no coal is dropped into the skip pit when the gate is being opened and closed.

The skip being charged with coal, is hoisted by a motor drive to the top of the tower, when the skip is automatically dumped, its contents going to a double set of crushing rolls, from which the crushed coal goes to a receiving hopper and from which it is delivered into cable-drawn railway cars. When being filled, these cars are on a track scale, Fig. 14. Each car has a cable grip which is tightened on the endless cable by a handscrew. The cable, which is kept taut by a counterweight suspended at the right of the tower, runs around guide pulleys at the curves and on rollers on straight runs from the tower to the coal bunker in the boiler house, at the left of Fig. 13, and returns through the other boiler house.

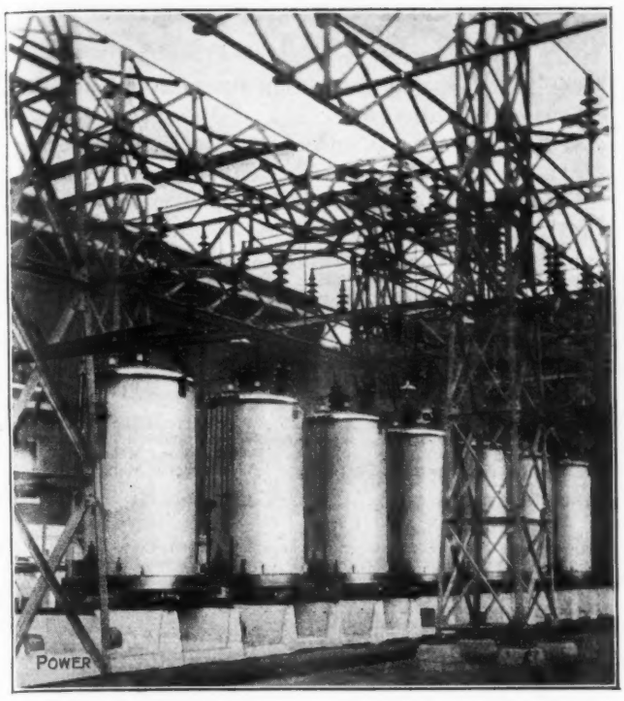


FIG. 19. TRANSFORMER AND CONCRETE FOUNDATIONS

A tripper, which can be placed at any desired point over the bunkers, automatically dumps the car load. A single pull of a lever resets the side doors of the car ready for a new load. From the bunker, the coal is delivered to the stokers through chutes, of which there are two for each boiler, with one bunker outlet. The maximum capacity for hoisting, crushing and conveying lump coal is 150 tons per hour.

As soon as conditions permit, a coal-storage space will be provided in the yard. Reclaiming tracks will run to this supply, which when needed can be loaded into cars and dumped into the coal hopper for hoisting to the crushing rolls. Fig. 15 is a plan view of the plant, showing the coal-storage area on the near side.

The present structures are ample in size for double the rated generating capacity of the present equipment. The foundations for the two stacks for the second boiler house are already built. When the additional equipment is in, the plant will have a turbine capacity of 41,200 kv.a. and a boiler output of 14,400 hp.

ELECTRICAL CONTROL

The control room is on the front of the turbine building and level with the turbine-room floor. Here are the bench board and measuring instruments, Fig. 16, for remote control of the low- and high-tension switches, a chief engineer's office and a chart room. On the ground floor are the storage batteries, power and lighting transformers and toilet room. All low tension oil switches and busses are in concrete cells on the ground floor of the turbine building. A wiring diagram of the power house is shown in Fig. 18. All high-tension apparatus is outside the building. The steel supporting frames, transformer, disconnecting switch, choke coils, circuit-breakers and electrolytic lightning arresters are shown in Fig. 17. There are seven 2750-kv.a. outdoor-type transformers, which raise the voltage from 6600 to 44,000 volts. They are single-phase, 60-cycle, and their high- and low-tension sides are connected delta. The transformers, Fig. 19, rest on a wheeled platform, which is supported by rails on concrete stringers laid on a concrete foundation. A track runs in front of the transformers to a repair house at one end of the steel structure. If a transformer needs attention, it is pushed on the car and taken to the house for repairs. Beneath the transformers are oil pipe lines. These are so arranged that disconnecting is simple, and the oil in the transformers can be changed while they are on the line.

TRANSMISSION LINES

The main transmission line is 46 miles long, extending from the plant to Beckley. The line is sectionalized at four division points, where frames carrying switches are placed for cutting out the section in case of trouble with one circuit. A diagram of the line connections is shown in Fig. 20. The steel main line poles and square anchor towers carry crossarms for double power circuits and two ground wires. The power cables are of 000

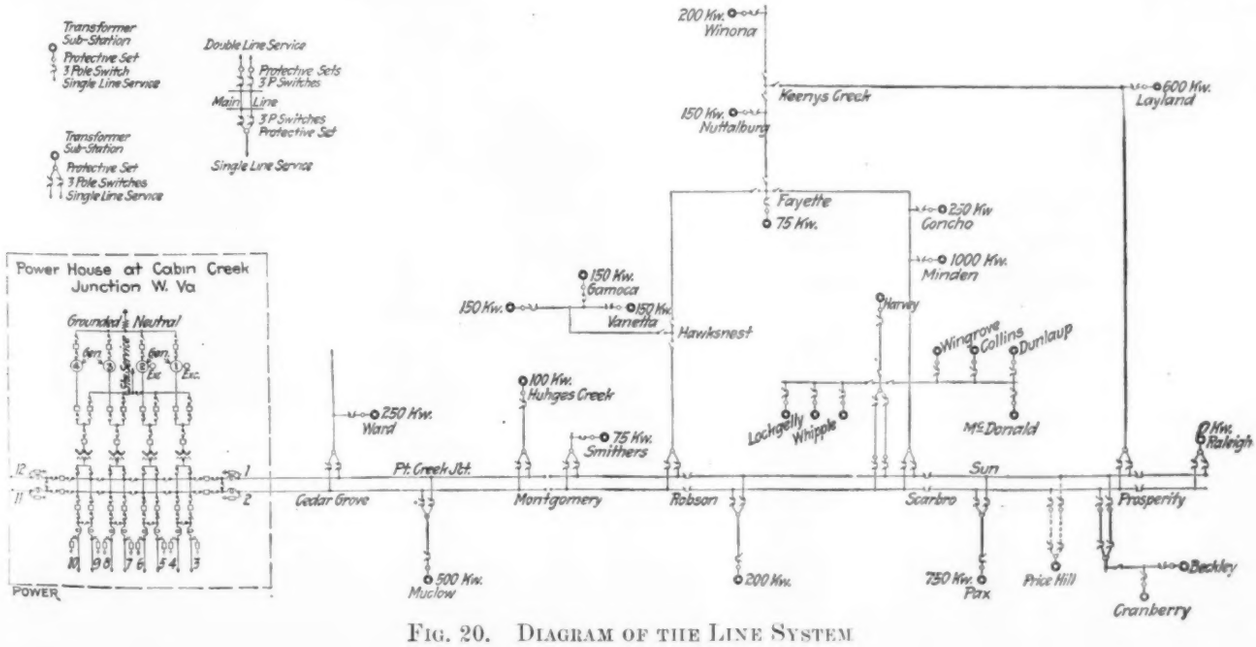


FIG. 20. DIAGRAM OF THE LINE SYSTEM

seven-strand copper wire. The 3/8-in. ground cables are seven-strand galvanized wire. There are a large number of distribution branches led off from both main circuits by take-off frames.

Three-disk suspension insulators are used on the power circuits, with four disks used for strain.

The Virginian Power Co. also owns sites on the New River, all in the immediate vicinity of the bituminous coal fields of West Virginia and eastern Kentucky. The total power which it would be possible to develop from these sites is 170,000 kw., and if operated on 30 per cent. load factor, the assumed power which could be generated would be 450,000,000 kw.-hr.

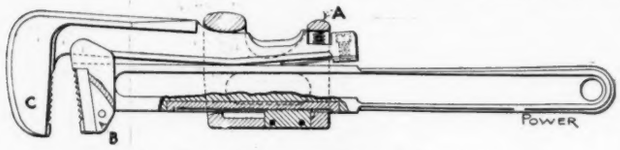
PRINCIPAL EQUIPMENT OF THE VIRGINIAN POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Turbo-generators	Double flow	10,300 kv.a.	Main units	1800 r.p.m., 185 lb. steam, 50 deg. superheat, 5-phase, 60 cycles, 6600 volts	Westinghouse Co.'s
2	Exciters	Self contained	90 kw.	With main turbo generators	Direct coupled, 1800 r.p.m., 125 volts	Westinghouse Elec. & Mfg. Co.
1	Exciter	Direct current	100 kw.	Stand-by unit	1800 r.p.m., 125 D. C. volts	Westinghouse Elec. & Mfg. Co.
1	Turbine	Single stage	100 kw.	Drive stand-by exciter	2400 r.p.m., 185 lb. steam, 50 deg. superheat	Westinghouse Mch. Co.
2	Condensers	Leblanc	No. 20	With main turbine	28-29-in. vacuum	Westinghouse Mch. Co.
2	Turbines	Re-entry	250 hp.	Driving condenser pumps	185 lb. steam 50 deg. superheat, 700 r.p.m.	Westinghouse Mch. Co.
2	Pumps	Vertical cent.	24 in., 17,000 gal. per min.	Water to house flume	Motor driven, 385 r.p.m.	I. P. Morris Co.
1	Pump	Vertical cent.	18 in., 8500 gal. per min.	Water to house flume	Turbine driven, 550 r.p.m.	I. P. Morris Co.
2	Motors	Induction	320 hp.	Driving vertical pumps	385 r.p.m., 440 volts, 3-phase, 60 cycles	Westinghouse Elec. & Mfg. Co.
1	Turbine	Vertical	165 hp.	Drives vertical pump	550 r.p.m., 180 lb. steam, 50 deg. superheat	Terry Steam Turbine Co.
1	Pump	Double suction, cent.	6 in., 1200 gal. per min.	Transfer water to 50,000 gal. tank	1760 r.p.m., motor driven	R. D. Wood & Co.
1	Pump	Double suction, cent.	6 in., 1200 gal. per min.	Transfer water to 50,000 gal. tank	1760 r.p.m., turbine driven	R. D. Wood & Co.
1	Motor	Induction	75 hp.	Driving transfer pump	1760 r.p.m., 440 volt, 3-phase, 60-cycle	Westinghouse Elec. & Mfg. Co.
1	Turbine	Single stage	75 hp.	Driving transfer pump	1760 r.p.m., 185 r.p.m., 50 deg. superheat	Westinghouse Mch. Co.
2	Heaters	Open, Cochrane	10,000 hp.	Heating feed water	Using exhaust steam from auxiliaries	Harrison Safety Boiler Works
2	Pumps	Triplex	400 gal. per min. cap.	Boiler feeders	3000 r.p.m., work against 200 lb. pressure	Westinghouse Mch. Co.
2	Turbines	Single stage	96 b.hp.	Driving boiler feed pumps	3000 r.p.m., 185 lb. steam, 50 deg. superheat	Westinghouse Mch. Co.
12	Boilers	Rust, water tube	600 hp. each	Steam generators	185 lb. steam, 50 deg. superheat	Babcock & Wilcox Co.
12	Stokers	Murphy, automatic	8x12 ft.	Dutch oven furnaces	Engine driven, natural draft	Murphy Iron Works
2	Stacks	Steel, lined	11'4" inside dia., 262' high	One for each six boilers	Natural draft	M. B. Pollock
1	Tower hoist	Steel	150 tons coal per hr.	Handling coal and ash	Motor drive	C. W. Hunt Co.
1	Transformer system	Outdoor type		For line service	6600 to 44,000 volts	Westinghouse Elec. & Mfg. Co.

Harvey's Improved Wright Pipe Wrench

The wrench consists of but practically three working parts, the rocking jaw, the handle and the yoke that joins the two. The soft iron rivet, a weak point in the old wrench, has been eliminated, although the movable jaw has the same rocking motion necessary to the bite and release action of the wrench.

The illustration shows the design. The wrench is operated by holding it in one hand, pressing down with the thumb on *A* and at the same time pushing forward or pulling back the yoke. When adjusting the wrench, the jaws are opened wide and the point of the lower jaw *B* placed against the side of the pipe. Then the rocking jaw *C* is pulled with the thumb until its point touches the pipe, when the thumb is released and the jaws are dropped over the pipe.



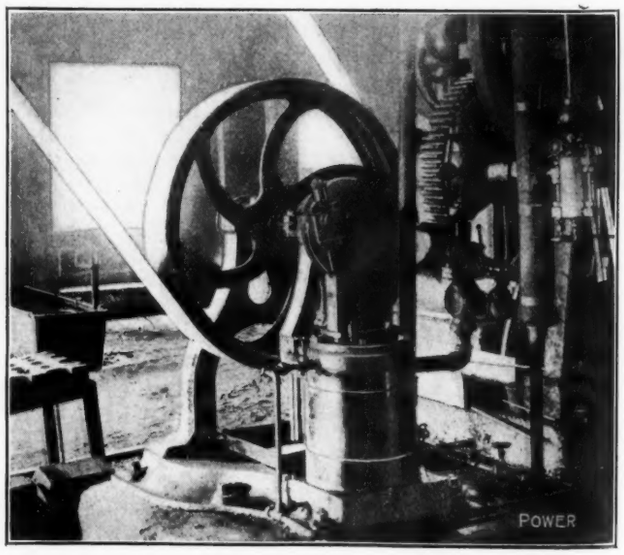
IMPROVED WRIGHT PIPE WRENCH

This wrench is made by A. Harvey's Sons Manufacturing Co., Ltd., First and Woodbridge St., Detroit, Mich.

An Old Steam Engine

BY D. O. BARRETT

The accompanying illustration shows an old steam engine which is still in operation at Mansfield, Ohio. It is of the vertical type, and appears to be single-acting; this, however, is not the case. There are no crosshead and piston rod as is usual in the double-acting steam engine. Instead, the piston is extended out through one end of the cylinder, as shown. As this extension is hollow it allows sufficient space for the movement of the connecting-rod, one end of which is pivoted in the piston proper. This, of course, materially cuts down the effective area of one end of the piston. It is extremely hard to pack this end and prevent steam leakage from the cylinder.



PECULIAR DESIGN OF STEAM ENGINE

The engine is used for driving power hammers and punches in the forge shop. Its age is 35 years; perhaps more.

A 4000-Hp. Single-Stage Centrifugal Pump

By Dr. Alfred Gradenwitz

At the Funghera electricity works of the Società Alta Italia (near Turin), there has been in operation for a short time a centrifugal pump, Fig. 1, remarkable both for its efficiency and dimensions. The most important feature of this single-stage pump, constructed by Messrs. Sulzer Bros., of Winterthur, Switzerland, is that a single rotor is used to deal with a maximum barometric head of 498.6 ft. and a maximum output of 475.5 gal. per sec. at 1002 r.p.m.

This pump serves to accumulate water and is intended at given intervals to raise the contents of a suction tank into an elevated storage reservoir. The suction and discharge heads are bound to increase during pumping, as the suction tank is emptied and the storage reservoir filled, and these fluctuations must not entail any reduction in efficiency; the constructors, in utilizing the available energy to the best advantage, had to solve a difficult problem.

Fig. 2 illustrates the working conditions. The storage reservoir has a capacity of 11,000,000 gal. The guaranteed power consumption for the whole duty of the pump is 29,000 kw.-hr., corresponding to 0.0026 + kw.-hr. per gal. of raised water. On tests on delivery, however, this guaranteed figure was not reached. The geodetical head, at the beginning of pumping—i.e., with the lower tank filled and the upper tank emptied—is 440.5 ft. and at the end, 496. The head thus fluctuates

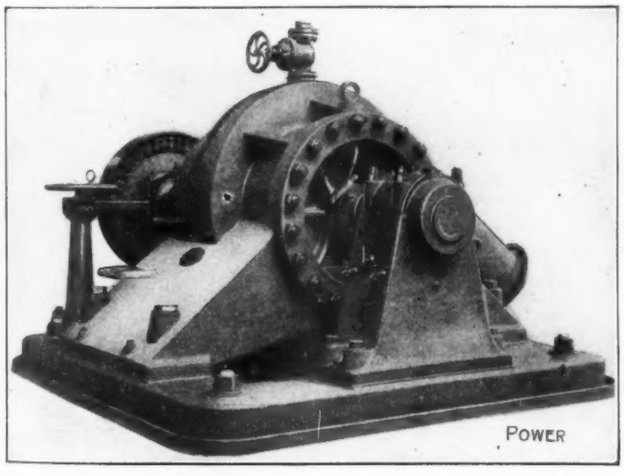


Fig. 1. Single-Stage Centrifugal Pump

each time about 55.8 ft. The output of the pump, at the beginning, when the head is a minimum, should be 475.5 gal. per sec., and while slightly decreasing as the head grows, should allow the whole amount of 11,000,000 gal. of water to be lifted in about 8½ hours.

Curve A illustrates the growing of the water level in the upper tank and curve B the falling of the level in the lower one. Both are approximately rectilinear, and the same applies accordingly to curve C, which represents the growing of the suction head. Curve D shows the amount of water raised per second at different times of working, and curves E_1 and E_2 show the behavior of the manometrical and geodetical heads. The difference between these heads, during the second half of the pumping operations, is considerably smaller than during the first. This is due to the pump, at the beginning, in dealing with the small geodetical head, having to be partly throttled by the regulating slide. After about 3½ hr. working of the pump, a condition is reached with a geodetical head of 485.4 ft., when there is no longer any need for throttling the regulating slide.

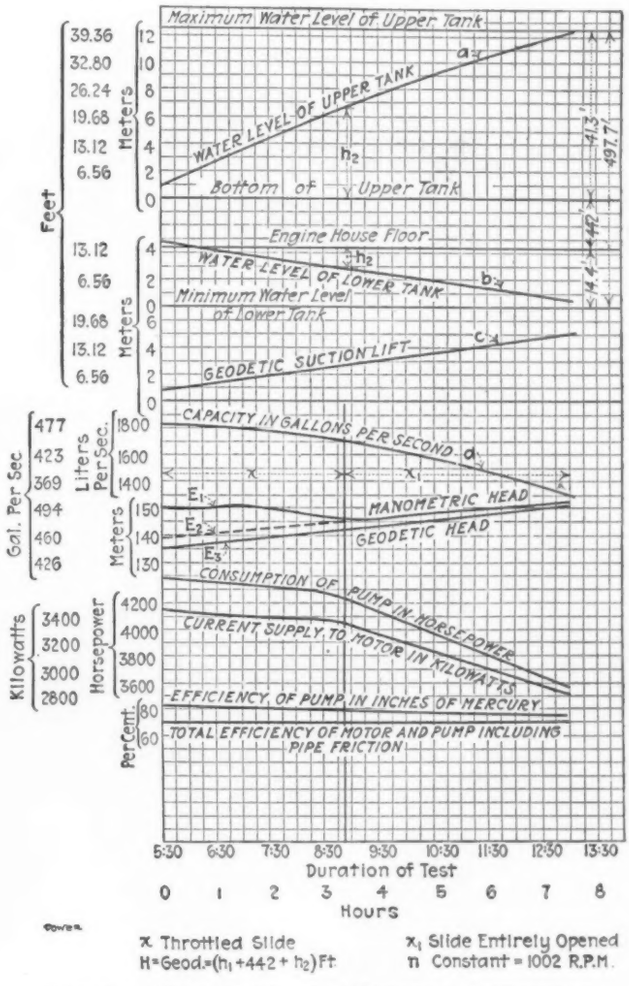


Fig. 2. Chart Showing Working Conditions

These curves show the pump to adapt itself in a high degree to various heads, lifting relatively small amounts of water at the beginning when working under a low head. While this adaptability could have been driven even slightly farther by chosing a somewhat larger motor-generator set, the immaterial improvement of efficiency thus attainable would not have warranted the extra cost. The dotted auxiliary curve E_3, which is based on the imaginary hypothesis that throttling by means of the regulating slide is not required, allows the amount of work expended in throttling, during the first stage of op-

eration, to be gaged. When distributed over the whole time of working plus this would not even amount to 2 per cent. of the whole work.

The curves show the efficiency, as referred to the barometrical head, to rise to 81 per cent. during times of heavy loads on the pump in throttling. The extremely high total efficiency of 70 per cent. for the pump, inclusive of the motor and conduits—that is, the efficiency, as referred to the geodetical head—should be noticed. The straight course of the curves also shows the total efficiency to remain constant during the whole time the pump was in operation, which, during the throttling stage, was working under especially advantageous conditions, as may be seen.

Reducing an Engine Test to Guarantee Conditions

By R. H. Corbett*

A Nordberg poppet-valve engine, sold to the United States Metals Refining Co. for its Grasselli plant, was guaranteed to produce a horsepower-hour on 10.9 lb. of steam under the conditions stated in the first column of the following table. On its acceptance test it required 11.015 lb., but the conditions were those shown in the second column:

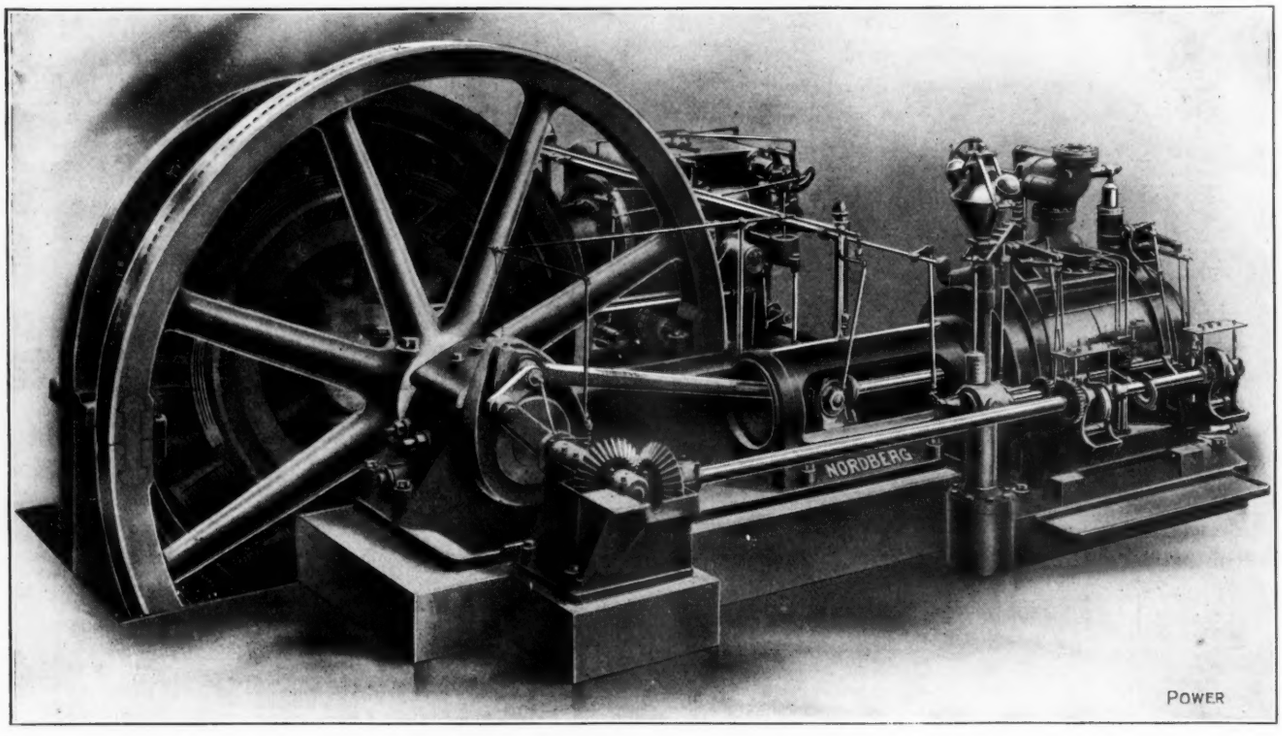


Fig. 1. Nordberg Cross-Compound at Grasselli Plant, U. S. Metals Refining Co.

	Guarantee	Performance
Initial pressure, lb. gage	150	154.78
Back pressure, in. mercury abs.	4	3.9
Superheat, deg. F.	100	76.15
Steam rate, lb. per i.hp.-hr.	10.9	11.015

In view of the lower superheat furnished it and the departure of the other conditions from those of the contract, did the engine meet its guarantee?

This was determined by comparing the Rankine efficiencies of an engine using 10.9 lb. of steam under the conditions of the contract and 11.015 under the conditions of the test.

The number of B.t.u. convertible by an engine of 100 per cent. efficiency working between given limits may be found by the following formula, the derivation of which appeared in Power of February 2, 1909, page 225:

$$U = H_1 - h_2 - (N_1 - n_2)T_2$$

U = Heat convertible by a 100-per cent. engine working in Rankine cycle in B.t.u.;

H_1 = Total heat per pound of steam in initial condition;

h_2 = Heat of the liquid, per pound in final condition;

N_1 = Entropy of steam in initial condition;

n_2 = Entropy of water in final condition;

T_2 = Absolute temperature of steam in final condition = Fahrenheit temperature t_2 due to back pressure + 459.64.

This gives the number of B.t.u. which a 100 per cent. engine could get out of a pound of steam. Multiply it by the number of pounds of steam used per horsepower-hour, and it gives the B.t.u. which a 100 per cent. en-

*Representative of the Nordberg Mfg. Co.

gine could get out of the steam, which the engine uses. A horsepower-hour is equivalent to

$$\frac{33{,}000 \times 60}{777.52} = 2546.56 \ B.t.u.$$

This is what the engine actually got out of a given amount of steam; the figure above derived is what a 100 per cent. engine would have got out of it. The former divided by the latter is the so called "Rankine" efficiency of the engine. This is worked out for the two cases below, the values being derived from the Marks-Davis tables of the physical properties of steam.

GUARANTEE CONDITIONS

150 lb. gage
14.4 barometer

164.4 lb. abs. initial pressure | 4 in. mercury abs. back pressure | 100 deg.zF. superheat

$N_1 = 1.6273$ $t_2 = 125.48$ | 1251.94 = H_1
$N_2 = 0.1738$ 459.64 | 93.38 = h_2
| 1158.56 = $H_1 - h_2$
$N_1 - N_2 = 1.4535 \times 585.12 =$ | 850.47 = $(N_1 - n_2)\ T_2$
| 308.09 = $H_1 - h_2 - (N_1 - n_2)\ T_2$
| 10.9
| 3358.18) 2546.56

75.8 per cent.

TEST CONDITIONS

154.78 gage
14.4 barometer

169.18 lb. abs. initial pressure | 3.9 in. mercury abs. back pressure | 76.15 deg. F. superheat

$N_1 = 1.6075$ $t_2 = 124.55$ | 1236.84 = H_1
$N_2 = 0.1722$ 459.64 | 92.45 h_2
| 1144.39 = $H_1 - h_2$
$N_1 - n_2 = 1.4353 \times 584.19 =$ | 838.49 = $(N_1 - N_2)\ T_2$
| 305.90 = $H_1 - h_2 - (N_1 - n_2)\ T_2$
| 11.051
| 3380.5) 2546.56

75.3 per cent.

It will be seen that the efficiency with which the engine performed under the test conditions is practically that with which it would have been required to perform under the test conditions to meet the guarantee, which was, therefore, considered as having been accomplished. The figures of the test are as follows:

DUTY TEST OF NORDBERG CROSS COMPOUND CONDENSING POPPET VALVE ENGINE

Made by Nordberg Manufacturing Co. and the United States Metals Refining Co., on engine located at the United States Metals Refining Co's. Grasselli Plant, to determine steam consumption per indicated horsepower.

Diameter—high pressure cylinder, in.	19
Diameter—low pressure cylinder, in.	44
Stroke, both cylinders, ft.	3.5

Date of test—October 1st, 1913

Total Quantities, Time, Etc.

Duration of test, hr.	10
Water fed to boilers during test, lb.	72,307
Loss of steam from boilers and pump leakage during test, lb.	3928
Total water charged to engine, lb.	68,379
Water charged to engine, per hr., lb.	6837.9

Pressures

Steam at throttle, lb. per sq.in.	154.78
Barometer, 29.316", lb. per sq.in.	14.4
Absolute steam pressure, lb. per sq.in.	169.18
Absolute back pressure, lb. per sq.in.	1.91
Receiver pressure, lb. per sq.in.	6.35
Pressure in low pressure jacket, lb. per sq.in.	25.0

Temperatures, Deg. F.

Steam at throttle, deg. F.	444.24
Corresponding superheat at throttle, deg. F.	76.15
High pressure exhaust, deg. F.	232.1
Low pressure inlet, deg. F.	239.52
Corresponding superheat, deg. F.	7.42
Feed water, deg. F.	104.4
Air in engine room, deg. F.	84.8
Steam at boilers, deg. F.	490.28
Corresponding superheat at boiler, deg. F.	122.78

Electrical Readings

Ammeter on switch board	4639.76
Voltmeter on switch board	86.03
Kilowatts, corresponding	399.17
Horsepower corresponding	535.07

Speed

Average revolutions per min.	100.34
Piston speed, ft. per min.	702.38

Power Developed

High-pressure cylinder, i.hp.	312.46
Low-pressure cylinder, i.hp.	308.38
Total power developed	620.84
M.E.P. in high-pressure cylinder	52.605
M.E.P. in low-pressure cylinder	9.557
M.E.P. in high-pressure cylinder referred to low-pressure	9.511
Total M.E.P. referred to low pressure cylinder	19.068

Efficiency Results

Steam per indicated hp. per hr., lb.	11.015

A photograph of the engine is reproduced in Fig. 1. The heads, but not the barrels of both the high- and low-pressure cylinders, are steam jacketed. Poppet valves are used on the high-pressure cylinder, as shown in Fig. 2, but the low-pressure is fitted with Corliss valves, with separate eccentrics for the steam and exhaust. The engine has thus the advantage of valves with no frictional contact for use in the superheat and of the Corliss valve with its lesser clearance when the temperature has got below that at which there is likely to be any difficulty in lubrication. The valve gear on the low-pressure cylinder is of the Nordberg full-stroke type, permitting cut-off to occur at any point up to completion of the stroke. The Nordberg Co. was organized for the purpose of making a cutoff governor for slide-valve engines. The valve used in the governor was of the poppet or double-beat type operated by a separate eccentric and tripped by fly balls at each stroke, thereby converting the engine to which it was attached to an automatic engine. The governor was a success from the beginning and the step to the building of the poppet valve engine was a natural one.

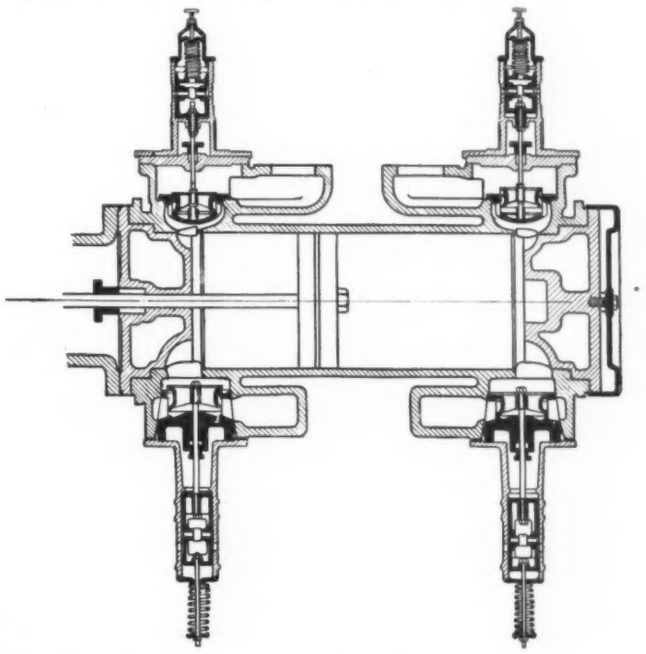


FIG. 2. CROSS-SECTION OF HIGH-PRESSURE CYLINDER

Mountains of Culm Disappearing—The mountains of culm which break the sky line throughout the anthracite coal region of Pennsylvania and which were for many years considered a nuisance are now being made to serve a useful purpose. There is at present a market for almost any grade of anthracite that will burn, and no more coal goes to the culm bank except for temporary storage and subsequent recovery by washers. These ranges of artificial hills, unsightly monuments to former waste, are contributing their share to the total coal production and are rapidly disappearing. Even the waste from the culm-bank washers is being utilized, for it is flushed into the mines and partly fills old workings where it cements together and furnishes support to the roof when the coal previously left for pillars is removed.

Ash Influence on Fuel Value of Small Anthracite Coal

By Frank G. Philo

The value of coal as fuel depends not alone upon the total number of heat units, or B.t.u. per pound, but upon the fraction of the total heat contained which can be produced under actual conditions of combustion and operation. The B.t.u. value of one coal as represented by a calorimetric determination may be higher than a second actually, but the lower B.t.u. coal often shows a higher actual fuel value. This can be seen when it is considered that the calorimetric determination does not include the moisture in the coal, as fired, the amount and composition of the ash, whether it contains excessive slag or clinker-forming constituents, or there are present such impurities as sulphur compounds, which in spite of their heat-producing properties are often the cause of partial corrosion of the boiler, the breeching and the bunkers.

The sample of coal tested by the calorimeter is usually burned in an atmosphere of pure oxygen, a condition much different from that in practice, where an atmosphere of only 21 per cent. of oxygen exists. It follows that the most practical way to determine the relative fuel value of different coals is to burn a considerable amount of each grade upon the grates and in the furnace under operating conditions and note the characteristics accompanying each grade.

Tables 1 and 2 and the charts, Figs. 1 and 2, show the results of tests during which over 20,000 tons of No. 3 buckwheat coal were fired and over 500 chemical analyses were made.

The coal used was fired into the same type of furnace and upon the same "sawdust" grate, having small circular air spaces ranging from $\frac{3}{32}$ to $\frac{1}{8}$ in. in diameter. The area of the air spaces represented about 8 per cent.

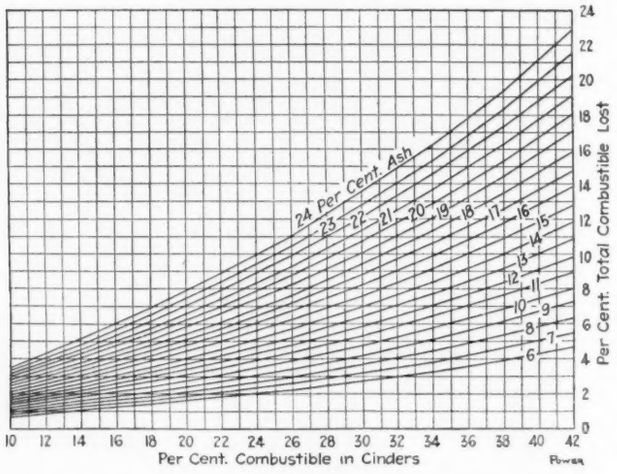


Fig. 1. Curves Which Designate Ashpit Losses

of the total grate area. Forced draft was used, and an average pressure of 1 in. of water. As practically no coal fell through the small openings, the fuel losses in the ashpits represented these, due to the combustible carried with the ash at cleaning periods, which, in this plant, occur once every six hours. It was found practically impossible to economically burn out more combustible after it had been burned until it represented about 18 per cent. of the material left on the grates after "pushing back." This fixed ratio of combustible to refuse mainly accounts for the rapid rate in which the

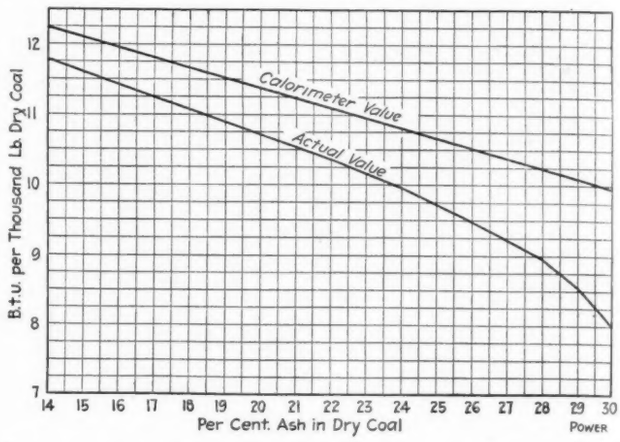


Fig. 2. Curves Showing Actual and Calorimeter Value of Fuel

losses in the ashpits increased with the higher ash coals. The percentage of the total combustible lost was calculated from the following formula:

$$\textit{per cent. total combustible lost} = \frac{(\textit{per cent. ash in dry coal}) \times (\textit{per cent. comb. in dry refuse})}{(100 - \textit{per cent. ash in dry coal}) - (100 - \textit{per cent. combustible in dry refuse}}$$

With anthracite as fuel, the value of the combustible in the refuse is almost the same as that of an equal weight in the coal fired, so no correction was applied. To simplify the calculation of ashpit losses the curves in Fig. 1 were plotted, based on the formula given.

TABLE I. COMPARISON OF THE CALORIMETER VALUE AND ACTUAL VALUE* OF DIFFERENT ASH COALS

Per Cent. Ash in Dry Coal	Calorimeter Value per Lb. Dry Coal B.t.u.	Actual Value per Lb. Dry Coal B.t.u.	Act. Value / Cal. Value Per Cent.
14	12,220	11,755	96.2
16	11,920	11,420	95.8
18	11,640	11,080	95.2
20	11,350	10,714	94.4
22	11,080	10,348	93.4
24	10,800	9,936	92.0
26	10,510	9,459	90.0
28	10,240	8,949	87.4
30	9,950	8,000	80.4

*The "actual value" of a pound of coal is here taken to mean the difference between the total B.t.u. contained in 1 lb. of dry coal fired and the B.t.u. in the combustible in the dry refuse per pound of dry coal fired.

TABLE II. CALORIMETER AND ACTUAL VALUES OF DIFFERENT ASH COALS AS COMPARED WITH 14 PER CENT. ASH COAL AS A STANDARD

Per Cent. Ash	Calorimeter Value: Cal. Val. of 14% Ash Coal Per Cent.	Actual Value: Act. Val. of 14% Ash Coal Per Cent.
14	100.0	100.0
16	97.5	96.9
18	95.3	94.1
20	92.9	91.0
22	90.7	88.3
24	88.4	84.5
26	86.0	80.5
28	83.8	76.1
30	81.4	68.1

The tables and curves will be found useful in calculat-

ing the penalties to be imposed for high ash when coal is to be purchased on specification. Although the actual values given will not apply to all sizes and kinds of coal, the actual-loss curve will be about the same. Of course, in computing the economic value of the different coals, due allowance must be made for the transportation costs, cost of handling the coal and refuse, and the increased depreciation and maintenance charges against the grates and stokers that accompany high ash and clinker. The reduction of the capacity of the boiler and the furnace must also be borne in mind, especially in plants where the boilers are required to operate at high overloads.

CO_2 as an Indicator of Boiler Efficiency

By M. K. Bryan

SYNOPSIS—Deals with the transfer of heat into boilers as indicated by the CO_2 content in the flue gases.

The efficiency of the furnace and grate is the ratio of the heat available for absorption by the boiler to the heat in the coal fired, and the efficiency of the boiler is the ratio of the heat absorbed by the boiler water to the heat available for absorption. Boiler efficiency, as usually expressed, combines these two and is that percentage of the heat of the coal fired which is absorbed by the water in the boiler. This is stated algebraically as follows:

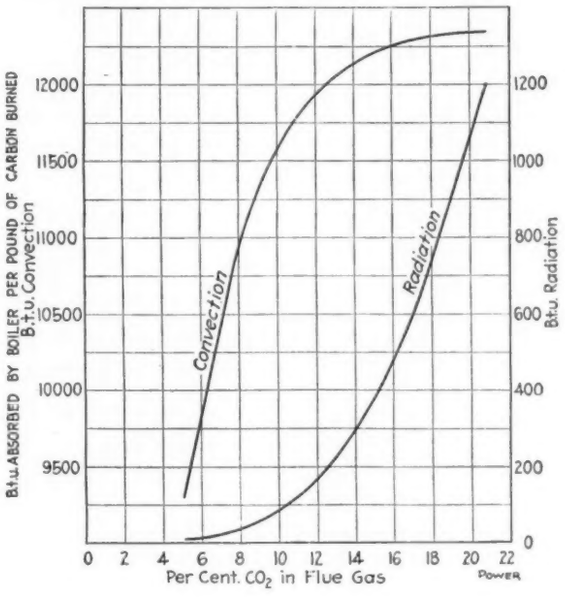


Fig. 1.

$$E = \frac{w\,(H - h)}{W H_1}$$

where

E = Boiler and grate efficiency;
w = Pounds of water evaporated in a unit of time;
W = Pounds of coal fired in a unit of time;
$H - h$ = Heat absorbed by one pound of water;
H_1 = The heat in one pound of coal as fired.

The above expression shows that E for a given installation depends upon the ratio $\frac{w}{W}$, and to increase the efficiency, more water per pound of coal must be evaporated.

This can be done by increasing the efficiency of the furnace and grate or by increasing the efficiency of the boiler. Increasing the tightness of the setting or the cleanliness of the heating surface, or perhaps changing the arrangement and properties of the gas passage, will increase the efficiency of the boiler, the efficiency of the furnace and grate not changing appreciably, but increasing the furnace and grate efficiency necessarily increases the efficiency of the boiler.

Increasing the furnace and grate efficiency without changing their design is, primarily, a question of air supply, generally, a reduction of air supply. The quantity of air supplied is indicated by the percentage of CO_2 in the gases of combustion, and the character of these gases, which is indicated by the percentage of CO_2, largely determines the combined efficiency of the unit because of the laws governing the transfer of heat from the products of combustion to the water in the boiler and because it depends upon the sort of combustion taking place.

The modes of heat transfer to the water in the boiler are by radiation from the fire and by convection from the gases to the outside of the water-heating surface, then by conduction to the inside of the heating surface—that is, through the metal and then by conduction from the inside of the heating surface to the water.

Radiation of heat from the furnace to the heating surface depends directly upon the difference of the fourth powers of the temperature of the furnace and that of the outside of the heating surface. It is expressed by the formula

$$H = K\,(T^4 - t^4)$$

in which H is the heat radiated from the furnace, whose temperature is T, to the outside of the heating surface having the temperature t; K is a constant dependent upon the relative positions of the radiating surfaces and the heating surfaces, and the units in which H is expressed. Fig. 1 has a radiation curve showing the heat radiated from a furnace to the heating surface plotted against CO_2 percentages. Note the increase in CO_2 following the increase in furnace temperature; see Fig. 2. The transfer of heat by convection from the gases to the heating surface depends directly upon the difference in temperature of the gasses and the heating surface and upon the weight of gas passing over the surface and indirectly upon the area of the gas passage. The amount of heat so transferred is stated by the formula

$$H = \frac{KW\,(T - t)}{A}$$

in which H is the heat transferred to one square foot of heating surface by a pound of gas and $(T - t)$ is the temperature difference of the gases and the heating surface, k being a constant.

The further transfer of this heat by conduction through the heating surface depends directly upon the temperature difference of the two sides of the metal and upon the composition of the metal, and indirectly upon its thickness. The transfer of heat from the inside of the heating surface to the water is dependent upon the rapidity of circulation, the character of the surface and

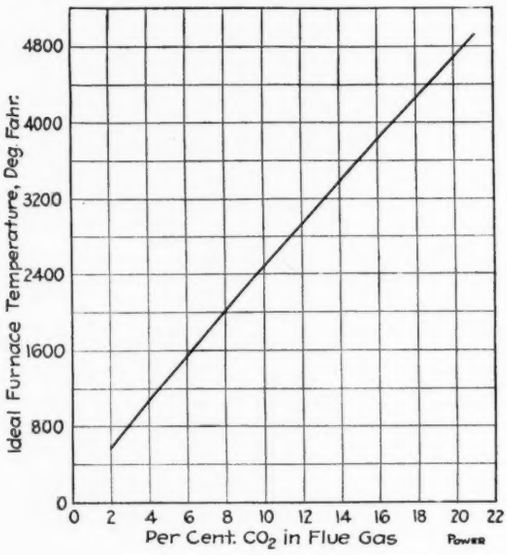


FIG. 2.

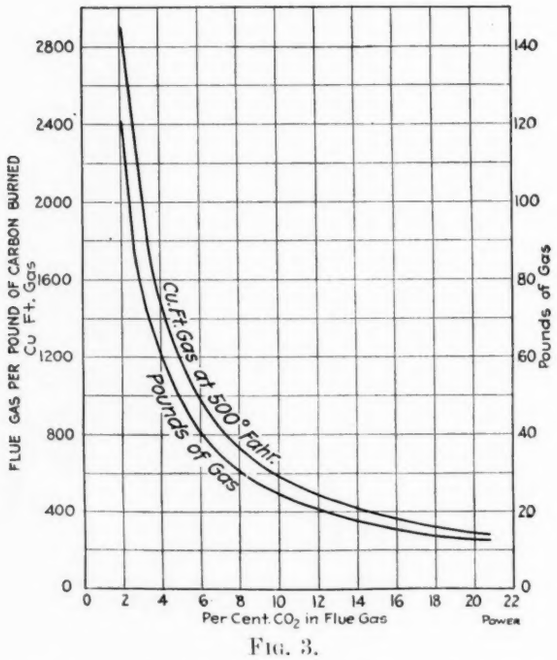


FIG. 3.

the difference in temperature of the surface and the water.

The transfer of heat through the boiler to the water is dependent, then, upon the design of the boiler, and the modern boiler is of such design that only a comparatively small difference in temperature is necessary here to take care of the heat transferred, even when the boiler is being operated at several times its rated capacity.

The curve marked convection in Fig. 1 shows the increase in heat so transferred as the CO_2 percentage increase, and this is due to increased furnace temperature. Fig. 3 shows curves of volume and weight of the gases plotted against CO_2 percentages. It will be remembered that the weight of the gases is a factor in the convection of heat; this accounts for the shape of the convection curve.

In constructing the curves, Figs. 2 and 3, a fuel of pure carbon was considered as completely burned to CO_2, the varying percentages of CO_2 being due to different excesses of air supplied. The temperature plotted is the ideal of maximum temperature attainable. A pound of carbon requires 11.6 lb. of air to supply the oxygen for burning it, and the products of combustion weigh 12.6 lb., as shown in Fig. 3. These gases absorb the heat of combustion, or 14,500 B.t.u., and their temperature is increased from that of the metered air, 70 deg. to 4800 deg. F. However, if an excess of air is admitted and the CO_2 percentage is 6 instead of 20.8, the gases of combustion will weigh 41 lb. These gases now absorb 14,500 B.t.u., and the final temperature is lower because of the increased weight of gas to be heated.

It is clearly seen, then, that a good CO_2 percentage

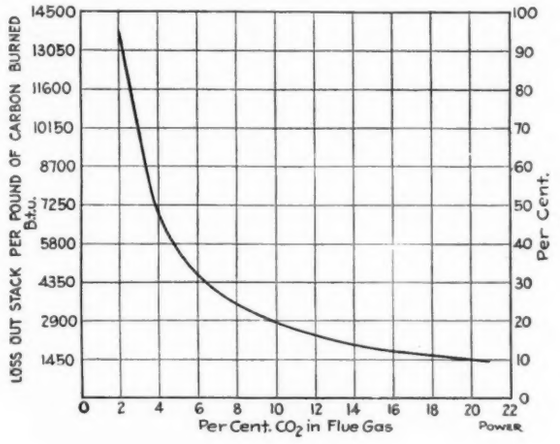


FIG. 4

means a good furnace gas temperature, and consequently a more rapid transfer of heat to the boiler than with lower CO_2 percentage. This means better boiler efficiency.

The greatest loss of heat, and consequently efficiency, is the heat carried away in the escaping gases. Fig. 4 shows a curve of the heat carried away in stack gases at 550 deg. F. plotted against CO_2 percentages. The heat is expressed in B.t.u. and as a percentage of the heat in the fuel. The factors entering into this loss are stack temperature and the weight of gas per pound of fuel. Each pound of gas leaving the boiler requires 0.24 B.t.u. to raise its temperature one degree—i.e., its specific heat is 0.24. If the air entering the furnace has a temperature of 80 deg., and the gases leaving the boiler have 550 deg., they will carry out 113 B.t.u. per pound, this being the quantity of heat taken up from the coal in raising their temperature to 550 deg. If the escaping gases have a temperature of 80 deg. the heat of the coal carried away is zero. It is, however, impossible to obtain a stack temperature less than that of the water in the boiler, which at 150 lb. gage pressure is 366 deg.

Under this condition there is a necessary loss of 68.5 B.t.u. per pound of gas, which amounts to 865 B.t.u., or 6 per cent. of the heat of the coal with the minimum of gas and 20.8 per cent. CO_2. However, the cost of the additional heating surface to attain this low figure is prohibitive and the loss must be kept to a minimum by reducing the products of combustion—i.e., increasing the CO_2. With a stack temperature of 550 deg., Fig. 4, shows a minimum loss of 10 per cent. with 20.8 per cent. CO_2. With 10 per cent. CO_2 in the stack gases, 25 lb. of gas per pound of fuel, the loss is 19.5 per cent., while with 6 per cent. CO_2 in the stack gases, 41 lb. of gas per pound of fuel; the loss is 32 per cent. or an increase of 64 per cent. caused by increasing the weight of the gases 64 per cent.

These considerations of the laws of heat transfer and combustion show that good CO_2 in the flue gases is an indication of proper overall efficiency, other things being equal, for with good CO_2 in the flue gases there will be good CO_2 in the furnace. Consequently, a good furnace temperature conducive to the efficient transfer of heat from the gases to the water in the boiler will result in a low stack temperature, and, further, there will be a small excess of air, meaning a less weight of gas out of the stack, which with the low stack temperature means a small loss.

High CO_2 percentages may be accompanied by considerable CO and the consequent loss, but, this condition is one of imperfect combustion, the result of faulty firing methods or improper furnace design for the requirements and does not argue against the value of CO_2 as an indicator of efficiency.

Influence of the Ignition Arch

By Joseph Harrington

SYNOPSIS—A discussion of the importance of early and rapid ignition in chain-grate stokers and the effects of a suitably designed ignition arch.

The influence of the ignition on the results of burning coal on a chain grate has not yet been fully appreciated even by those directly concerned with such matters.

In the issue of Power for Dec. 10, 1912, the writer set forth the principles governing the design of the ignition arch in its relation to the furnace in general, but more particularly to the fuel bed. Briefly, this showed how the ignition arch reflects heat from the rear or highly heated portion of both fuel bed and furnace brickwork to the front where the fresh coal enters.

An arch of this design is substantially a heat mirror. The correctness of the theory on which it is based has been so repeatedly demonstrated that this theory must now be accepted as definitely proved.

In the chain-grate type of automatic stoker the various steps in the progressive combustion of coal are perhaps more orderly and undisturbed than in any other, and the results of a proper completion of each of the various stages of combustion can be more readily and clearly followed. As in most mechanical processes as well as in the personal efforts of the individual, the old saying, "Well begun is half done," applies with particular force to the series of events occurring in the furnace. It must be clearly borne in mind that the complete combustion of coal involves an orderly series of events, which can be briefly outlined as follows:

The fresh fuel, containing some moisture, enters the furnace where it is subjected to the influence of the furnace temperature. The moisture is first driven off, which in any given particle of coal probably takes but a very short time. This is accomplished by the time the temperature of the particle of coal under consideration reaches the temperature of 212 deg. F., and as the temperature continues to increase, the volatile constituents begin to come off. If the temperature at the point of ignition is sufficient, these burn in the space above, and approximately as fast as they are distilled. The burning of this portion of the fuel forms one source of the heat required for the ignition of the succeeding charge or unit of fresh coal.

The volatile contents are not all driven off at the same temperature, so this portion of the process continues during an appreciable time or until the fuel has traveled some distance in the furnace.

Temperature readings taken at the point of ignition indicate that about 1100 deg. must be obtained before the volatile will properly ignite and 1300 deg. must be had if the ignition is to be prompt and bright.

About the time that the volatile is all gone the particle of coal has reached a quite high temperature and the fixed carbon begins to burn. That it requires considerable time to complete the combustion of the fixed carbon probably makes this step about the most noticeable and easily distinguished event in the entire combustion process. A higher temperature is required than for the volatile and on account of the solid nature of the fuel (which permits of its burning only on the surface), the proper completion of the combustion of the fixed carbon becomes one of great importance and some difficulty.

It is obvious that this particular stage must be begun as early as possible, in order that the end may be within the time limit of the chain-grate travel. A prolific source of inefficiency is the dumping of unburned fuel into the pit, and analysis shows that this is almost entirely fixed carbon.

Early and rapid ignition, therefore, becomes, as a consequence, vitally necessary to the proper completion of the entire process. I would divide the advantages to be gained into two main divisions:

1. The complete burning of the volatile contents at or near the front of the furnace results in smokeless combustion.

2. The early completion of the fixed carbon combustion reduces or eliminates the loss of fuel to the ashpit.

Smokeless combustion is unquestionably one of the most important and active subjects of discussion by engineers that at present occupies both the technical and non-technical world. Many strange devices for "burning the smoke" have been devised and unusual and expensive furnace designs have been built to accomplish the same

purpose. As often happens in such cases, the principal cause of smoke-laden gases has been overlooked. Smokelessness consists not so much in burning or eliminating smoke as it does in securing combustion that does not result in the production of smoke at all. When it is remembered that the gases arising from the fuel bed are in the furnace but a few seconds, it will be appreciated that every foot of flame travel must be made as effective as possible. Any delay in starting the combustion process seriously affects the ability to complete it before the gases leave the furnace.

The proper place to begin the work is at the instant when the gases leave the fuel in which they are bound up, and the brightest and most intense ignition is none too bright or too intense for this purpose.

Any ignition arch, therefore, that accomplishes this result becomes one of the most potent factors in the elimination of smoke. The reflecting arch, as has been referred to, actually accomplishes just these results.

Any combustible matter which may pass into the ash-pit is a direct and visible loss, and no arguments are needed to make this matter clear. As previously stated, however, the fixed carbon content of coal burns out more slowly than the volatile, and in the usual chain-grate setting a portion of it will pass into the pit unless its combustion is properly started and actively assisted.

This necessary assistance may be given by sustaining the temperature at the back of the furnace, so that the last portions of coke heavily mixed with ash may entirely burn out. There is no question but that the built-up bridge-wall is of great assistance under these circumstances. Indeed, some designers have gone so far as to build forward at this point, making a definite overhang.

From the standpoint of ignition, it is sufficient to obtain an expanse of incandescent brickwork at the rear of the furnace. The radiated heat from this wall is of definite value for ignition purposes and can best be utilized by the deflection arch. The design of this arch must be made with this in mind, that the face of the bridge-wall is, for ignition purposes, a source of heat similar to the fuel bed itself. The inclination of the arch must be determined with a view to catching this radiation.

Inasmuch as the termination of all of the events of the furnaces is directly dependent upon the beginning, any factor which contributes beneficially to the quality of that beginning becomes of prime importance. Furnace design has, heretofore, been seriously neglected with respect to ignition conditions and, apparently, we have been content with getting along as best we could with the ignition effect taking place several inches from the point of entrance. Or, if the ignition did reach the gate, we were content so long as any fire showed itself at all. Only under conditions producing a bright white flame just at the gate, should things be considered as in satisfactory shape. These conditions yield a wonderful stimulus to economical combustion and it is unlikely that intensity of ignition can ever be overdone.

Motors, Their Principles and Uses—I

By Gordon Fox

SYNOPSIS—This installment of the series takes up the relations between magnetic and electric circuits as bearing upon the fundamental operation of the electric motor.

The operation of all electric motors is based fundamentally upon the relations existing between magnetic and electric circuits. Magnetism can be considered as lines of force which follow a closed path through iron from south pole to north pole and through air from the north pole to the south pole. Magnetic materials possess low resistance to the passage of magnetic lines of force whereas non-magnetic materials possess high resistance. There is no total insulator of magnetism. The lines concentrate in a magnetic material, such as iron and spread in air. Fig. 1 shows how magnetic lines are distributed in the space between the poles of a magnet.

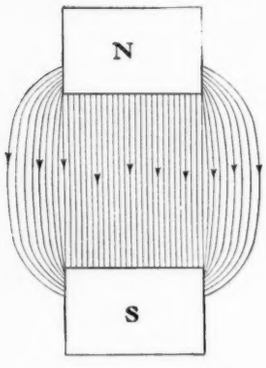


Fig. 1. Showing Magnetic Lines between Poles of Magnet

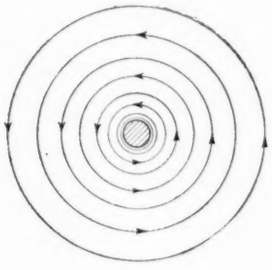


Fig. 2. Magnetic Lines Surrounding Conductors

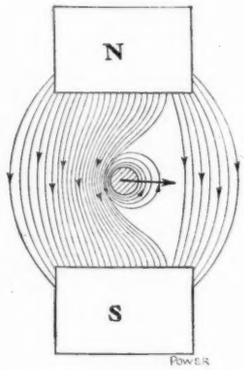


Fig. 3. Action of Magnetic Lines on Conductor Carrying Current

It was discovered by Faraday that a conductor through which an electric current is flowing is surrounded by a closed circuit of magnetic lines of force as shown in Fig. 2. It is evident that if a wire, carrying an electric current be placed in a magnetic field between two magnet poles the composite field resulting will be as shown in Fig. 3, the direction of the lines around the conductor depending on the direction of the current within it. The component lines of force are cumulative on one side of the wire and opposing on the other. Magnetic lines tend to seek the shortest path, hence those to the left of the wire tend to straighten out, acting similarly to elastic rubber bands and in doing so exert a sidewise force on the wire as indicated.

All electric motors are fundamentally dependent upon this principle for their action. They consist of electromagnetic fields mechanically arranged, usually upon an

outer stationary part, acting upon conductors carrying current and placed upon the circumference of a drum which is free to rotate. The forces acting upon the conductors as above explained set the drum into rotation. There is a slight clearance or air gap between the stationary and rotating parts. The magnetism passes from a north pole of the field across this air gap, through the iron

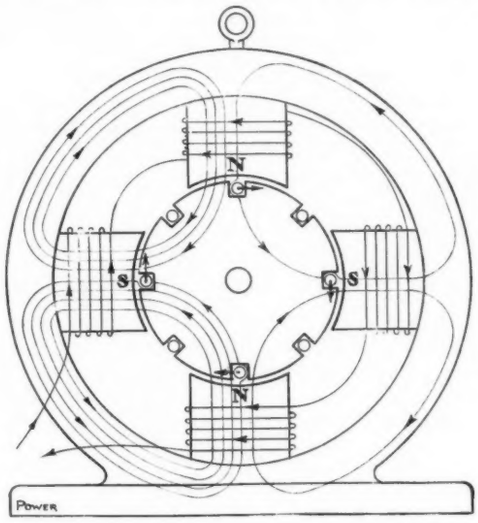


FIG. 4. ILLUSTRATING THE PRINCIPLE OF A SIMPLE MOTOR

drum and across the gap again into a south pole, thence through the iron frame to the north pole again. The magnetism is maintained in the fields through the action of electromagnetic coils as explained later. Fig. 4 illustrates the principle of a simple motor.

The value of the force exerted upon a conductor carrying current in a magnetic field is proportional to two items; the strength of the magnetic field and the amount of current in the conductor. This leads to the basic law in all electric motors that mechanical force or torque is proportional to magnetic flux times the electric current.

It can be further shown that if a conductor forming part of a closed electric circuit be moved across a magnetic field the lines of force, acting again like rubber bands, stretch and assume a distorted condition similar to Fig. 3. This distorted condition as was previously shown can be considered as the resultant of two distinct magnetic fields. One of these fields is a closed circuit about the wire and can only be formed in the presence of an electric current in the wire. It follows that there is actually set up in the wire an electric current due to the presence of the magnetic field about it. This may be made more clear if it is considered that the wire is moved across the field to the point where the elastic lines of force break near the poles and wrap themselves about the wire. The wire is then surrounded by magnetic lines of force which is the condition of a wire through which a current is passing. The current is in fact found to pass through the wire to satisfy the condition. The fundamental principle of the electric generator follows: When a conductor forming part of a closed circuit is passed across a magnetic field an electric current is set up in the conductor.

It is further found that when a wire is placed in a magnetic field of varying strength, that is, a field in which the intensity or direction of the magnetism is made to change, an electric current is set up in the wire, which tends to oppose this change. The greater the rate of charge, the greater the current produced in the wire. Upon this principle the electric transformer is based.

Summing up the fundamental principles; then

1. A conductor carrying an electric current in a magnetic field is subjected to a mechanical force at right angles to the wire and the field and proportional to the strength of the field and the value of the current.

2. A conductor of a closed circuit, moved across a magnetic field so as to cut the lines of force has set up in it an electric current the value of which is proportional to the strength of the magnetic field and the rate of cutting the magnetic lines.

3. A closed conductor placed in a magnetic field of varying strength has induced in it an electric current the value of which is proportional to the rate of change of the magnetism.

Returning to the principle that there is set up a magnetic field round a current-carrying conductor, the principle of the electromagnet is at once evident. A number of turns of wire are placed about an iron core which will not retain permanent magnetism to any considerable extent. When a current is passed through the wire the magnetic fields of the individual turns act collectively to cause the major portion of the lines of force to pass through the central iron core and through whatever magnetic circuit may offer the least resistance to the passage of the magnetic lines. Fig. 5 illustrates how the magnetic effects of the individual turns combine to form a

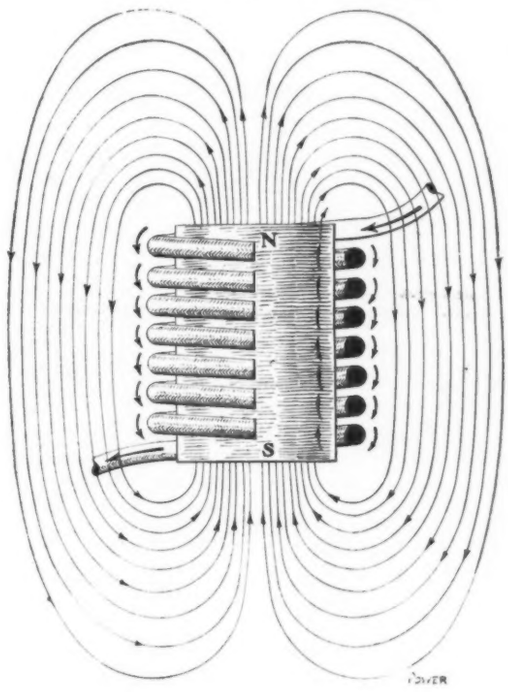


FIG. 5. MAGNETIC LINES OF INDIVIDUAL TURNS COMBINING TO FORM STRONG FIELD

strong resultant magnetism in the core. By changing the value of the electric current the strength of the magnetism is controlled. It is found that up to a certain point the strength of the magnetism, measured by the number of lines of force in a given area, varies almost directly with the strength of the magnetizing current. Above this point a greater increase of current is required

to cause an equal increase in magnetic density. This point is called the point of saturation and when the iron is magnetized above this point it is said to be saturated. Fig. 6 illustrates the saturation curves of iron, steel and air.

It is evident that when a conductor is moved past a north pole of a magnet it will have generated in it current in one direction and when moved past a south pole the current will be set up in the opposite direction, since the magnetic lines are reversed. Any electric generator consists of a mechanical arrangement by means of which electric conductors are made to move past alternately north and south poles. As the electric pressure or voltage generated in a single conductor is small, coils are made up of many conductors with their ends connected to form a continuous circuit. The connections are so arranged that the voltages in the wires under north and south poles all act cumulatively. Referring to coil *A*, Fig. 7, in the conductors under the north poles the current will flow down through the plane of the paper, away from the reader, and in those under the south poles, it will flow toward the reader. When the conductors have moved through one pole space (in this case 180 deg.) this direction will be reversed. Since the conductors are in series the currents in coil *A* will all be in the same direction.

In an alternating current generator the ends of these circuits form the terminals of the machine and the current which passes through the wires first in one direction and then in the other direction is called an alternating current.

At the instant the conductors pass the center of the poles the rate of cutting magnetic lines is greatest and

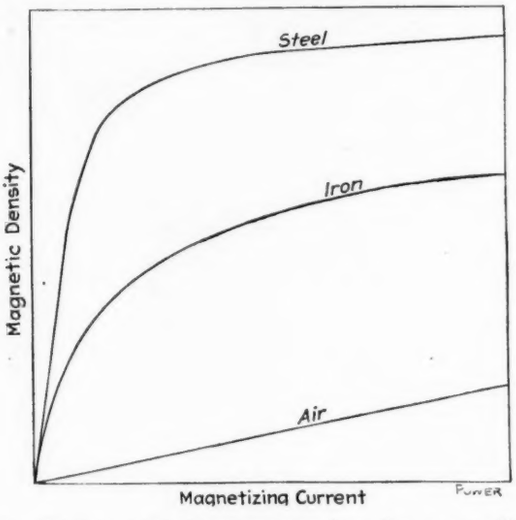


FIG. 6. SATURATION CURVES FOR AIR, IRON AND STEEL

the instantaneous voltage generated is a maximum. When they pass a point midway between the poles the voltage is zero. Fig. 7 illustrates how the magnetism is distributed under the poles of a generator and how the instantaneous voltages change. The voltage may be considered as starting at zero, reaching a maximum in a given direction, falling again to zero, reaching a maximum in the opposite direction and falling again to zero. This series of changes occuring when a conductor passes two poles or 360 magnetic degrees is called a cycle. The frequency is the number of cycles per second, 25, 60 and 133 being the common commercial frequencies.

Consider that when the first set of conductors is midway between poles, a second set of conductors is directly under the poles. At the instant the voltage in coil *A* is zero the voltage in conductors *BB* is a maximum. Such an arrangement occurs in a two-phase generator and the voltages are said to be displaced 90 degrees or "quarter phase." Similarly three sets of conductors equally spaced have generated in them voltages 120 electrical degrees apart; a generator with its coils so arranged being called a three-phase machine.

It is possible to bring the ends of the conductors on the rotating element of a generator or motor to a current

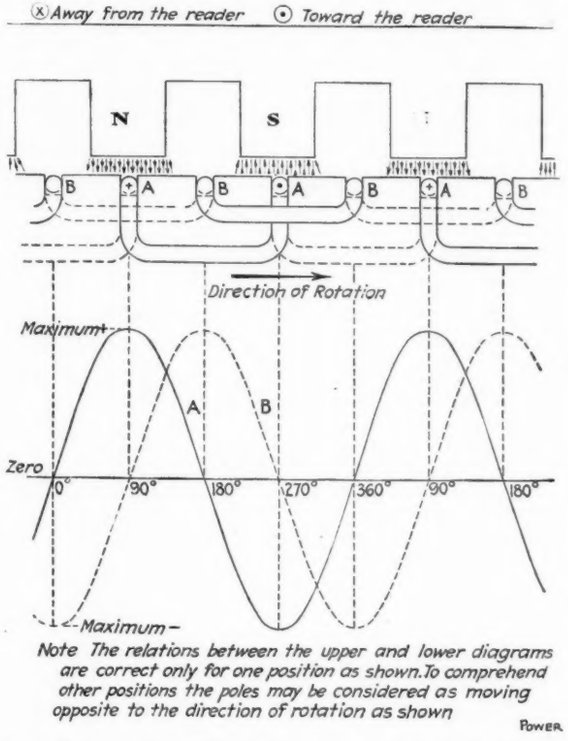


FIG. 7. ELECTRICAL RELATIONS IN TWO-PHASE WINDING

collecting device called a commutator which is made up of a number of copper segments separated by mica strips. If the brushes are placed at proper intervals, rubbing against this commutator, the current which is collected and passes through the external circuit connected to the brushes, is unidirectional and does not fluctuate in value as does an alternating current. This will be evident if it is noted that, the poles and brushes being fixed, their relative position is constant. The coils which deliver current to the brushes at any instant are therefore always in the same relative location with respect to the poles. It follows that the direction of the voltage in the coils connected through the commutator to the brushes is always the same. Stated in another way: The voltage generated within the conductors is actually alternating in value but the conductors deliver current to one set of brushes when passing under north poles and to the other set when passing under south poles. It will be seen then that these brushes, which lead to the terminals of the machine, are always of the same relative polarity hence in an external circuit between them the current will always flow in the same direction. This class of electric current is called direct current and a generator arranged to deliver it is called a direct-current generator.

Editorials

The Operating Engineer as a Purchasing Agent

"Well bought is half sold," is an old and true saying. Well bought means getting the thing which will produce the best results with the least money. A few years ago buying meant jockeying, bargaining, beating around the bush, with the idea that the buyer was entitled to no mercy if the seller could "put anything over on him." Today that is all very different. There are sporadic cases of downright dishonesty in selling, but they are so few, and it is so possible usually to correct them between the time of delivery of the goods and the paying of the bill that they may almost be considered a thing of the past. There does, however, remain a large opportunity for judgment on the part of the buyer and for good advice on the part of the salesman.

Every really good house is trying to send out men to sell its product that are really engineers, and who realize that their own personal interest as well as that of the firm lies in selling the thing which will best serve the purchaser. Not every firm has yet succeeded in getting all of this type of salesman that it needs, however. Until such a time, and for a long time after, the buyer will have to experiment to some extent, on his own account and discover for himself the peculiarities of his plant which demand treatment different from that of some neighboring one. Because a 500-hp. plant on one side of the street finds that Sam Jones' Triple JBX packing, or oil, or gage glasses give the best results under the care of Mike Jacobson is no sign that *you* cannot find a better packing to use, or a better coal to burn, or a longer lived gage glass, for your plant even though you have the same horsepower of boilers as the other.

A general purchasing agent is more than apt to be influenced by the fact, or the alleged fact that some large plant uses these brands, than he is by your unsupported statement that you have found something else better. The salesman comes in with a clean collar and nice looking shoes and you come in minus a collar and with shoes that you can work in. Your rig ought to appeal to the purchasing agent more than that of the salesman but it does not, and you cannot get to the manager to tell him about it, which is worse luck because the chances are he would understand you better than the agent does.

About the only recourse that is left you is in the way of records. If you can show that the X Y Z brand of cylinder oil carries you over 20 per cent. longer time than the A B C brand and you can show some nice looking cylinders he will probably never ask to take a look at them. If you can check up your pounds of coal against kilowatt-hours, you have a pretty far reaching argument. Of course, you may have to first get a watt meter, which is not always easy, but if you cannot get that your water meter ought to be somewhat better than no guide at all, even if all the other water for the plant comes through it. You can get records that may make the boss anxious to give you the proper instruments to really keep track of what you are doing.

You buy coal for the sake of what it will do under your boilers, not someone elses. There are two factors in what it will do, one is the coal and the other is you, or what you can get your fireman to do. The combined result is what the owner cares about. You cannot get credit for your part unless the coal does its part. So far there appear to be no scientific tests for coal that measure up to actual use. They give indications but that is about all. The test should be one that will take into account the temperament, or the more or less pure cussedness of the stoker. The mechanical stoker may eliminate psychology from the matter, but even then after manufacturers are through hugging themselves in glee over finding a stoker that will keep steam up with bad coal, they may find that there is still more profit in using good coal.

Doing the Hard Job

Certain jobs come to be regarded as hoodoos. They get talked over in meetings of engineers and no one wants to take them.

Sometimes they are the best jobs for a young man to get. When everything has run smoothly ever since a plant was first fired up there is no particular credit to either a new engineer or the old one for its performance. That is, there should be credit given but there is not. The man who makes his mark and impresses the world is not the one that comes along in time and stamps out a live cigar butt before the building catches fire but the one who comes at the last moment and "saves" the last man just as he was going to walk out unaided. This is all wrong. We worship the spectacular and we forget the man who really serves in a sensible way, but that is the way of the world and we will not have time to change it before we drop out of the running. So why not make something of it? If the world wants to be fooled why not fool it, especially when we can do it a good turn at the same time?

If a man can go into an engine room and straighten things out and put the plant where it will run every hour that the schedule calls for and do it where no one else succeeded, he is just the man that someone else is looking for. He probably has to do it with equipment that ought to be on the scrap heap, but if it is a stepping stone to something better why not do it? A man is better off with one earned failure back of him than he is with a dozen successful plants that "any fool" can run because many fools have. The thing that is worth while is to do something that not everyone can do. It is not always easy, it may be hard work and it may be hard thinking that brings success, but that is what our hands and our brains were given us for.

"He also serves who sits and waits" is a fine motto for an impatient man to hang over his desk but it has been the undoing of more than one engineer. Too often his

job is a sitting and waiting job to such an extent that he feels that he can sit and wait until something happens that makes him stir, and no man can afford to do that no matter what his position. If a man cannot get a job that is big enough to keep him fully occupied he is to be pitied. The little jobs are for the little men, the old worn-out men who must have an easy letting down. The job for the young fellow is something that will keep him on his metal and that will not allow him to become an old man before his time, it is a job that someone else cannot do that he needs, and that he needs to conquer.

The Advancement Prospect

"Shall I look for advancement in my present position or shall I endeavor to get ahead somewhere else?" Many of us are asking ourselves this same question.

That there is a decided preference among most employers to promote their own employees, gives the cue to the seeker after success. He will be more apt to find promotion, responsibility, and a competence for old age with present employers than with others who know nothing of him.

It sometimes happens, however, that a man finds he has traveled as far as possible in his present position and has come up against a wall and that further advancement is prevented by favoritism, prejudice, the small size of the business or some other cause. What is he then to do? Where can he turn for success, the success which his present environment forbids?

Our answer to such would be: Look for your future in the employ of some young and growing concern, in a line of work in which your experience has made you valuable. In any case one will find it advisable to begin low, and secure the confidence of his employer. One must demonstrate his fitness for a superior position before he can be appointed to it. If he works hard and intelligently, and makes his employers' interests his own in whatever capacity he may be, then, if there are any real opportunities above him, promotion will take care of itself.

Viewing the Load Curve from Different Angles

In many generating plants the operating force never gets beyond the simple load curve plotted with kilowatts output as ordinates and hours of the day as abscissæ, so far as this method of station-performance analysis is concerned. It is desirable to plot other relations of the load to the operating period, and among these are the total daily output in kilowatt-hours contrasted with the days of the month; a curve showing the successive daily peaks and minimum loads for a month; a curve of average daily loads carried through a month, and a curve showing the number of hours each month that a given maximum load persists. Then there are a number of instructive comparisons which can be made with little trouble on a yearly basis, plotting the values against the months and comparing this year's performance with last year's. Progressive developments of monthly maximum loads plotted against time are interesting, and if one wants to include the capacity of generators in service at particular periods, it does not take long to get into the realm of really scientific plant operation.

Variations between different factors in plant service are well worth reducing to graphic form when a man has time to devote to this sort of analysis, and the far-sighted engineer is apt to find time for work of this kind, if he sees its value. Keeping such data up to the times in loose-leaf form or in blueprints which can be turned over to the "boss" upon receipt of some sharp-angled inquiry is a practice which bears cultivation. The value of the ordinary load curve is beyond question and needs no argument, and the development of special curves fitting each plant along the lines above hinted is a fascinating and profitable study.

War vs. Efficiency

Good engineers hold that energy should be conserved—not wasted. For centuries they have labored to get the maximum work out of a pound of coal, and the maximum effect from a pound of explosive. Through efficiency applied to engineering billions of dollars have doubtless been saved.

Through the steam engine and the development of other power apparatus science has advanced by leaps and bounds. During the last century, because of the availability of cheap power there has been more up-building than in the ten preceding centuries. We, therefore, have good reason to take pride in our power achievements.

However, it is lamentable that man should make use of power in a destructive way. Our European brothers have struggled hard, as hard as we, in their fight to conserve energy and natural resources. Now much of their work is being ruthlessly razed to the ground, and the pity of it all is that power is the chief instrument of ruination.

The explosives used in bombs, mines, and guns would find much better use in the blasting of roadways, foundations and tunnels.

The coal that propels the battleships would be of much greater benefit in propelling commerce boats. The needless burning of coal only brings us so much nearer to the exhaustion of the world's coal supply.

The iron and steel that makes up the guns and the armament should be put into efficient machinery—boilers, engines, motors, lathes, etc.

Finally the men, who are now killing each other, should be usefully and peacefully employed in making better use of nature's gifts for their own development and for the benefit of posterity.

Don't lose sight of the fact that our foreword this week is founded on fact. Except for the names it is a true story. More than that, it pictures a situation that really exists and needs correction. If you need to, take the tip and brush up on alternating-current practice.

Any of our subscribers who receive post cards from us asking for information regarding boiler accidents will confer a favor if they will fill these out and return them as promptly as possible. We are trying hard to bring out the Boiler Explosion Table for the first half of this year but are meeting with a great deal of difficulty in getting the required information. Any help from our readers will be greatly appreciated.

Correspondence

Air-Compressor Testing

My attention has been directed to the article on this subject by W. C. Lancaster in the Jan. 6 issue of POWER. I believe, in view of the rapidity with which compressed-air applications are increasing and the correspondingly increased attention which engineers are giving to air compressors and allied machinery, that several of the statements made should not remain unchallenged.

(1) This is the formula used for the flow of air through an orifice,

$$G = 0.53\, F \frac{P}{\sqrt{T}}$$

where

G = Flow of air in pounds per second;
F = Total area in square inches of all orifices;
T = Absolute temperature Fahrenheit of the compressed air in the orifice chamber;
P = Absolute pressure in pounds per square inch in orifice chamber.

While mathematically correct, it makes no allowance for friction or for the effects of and disturbances due to eddies. Both of these result in losses not accounted for by theory and necessitate an empirical coefficient of discharge in order to compute the actual quantity of air

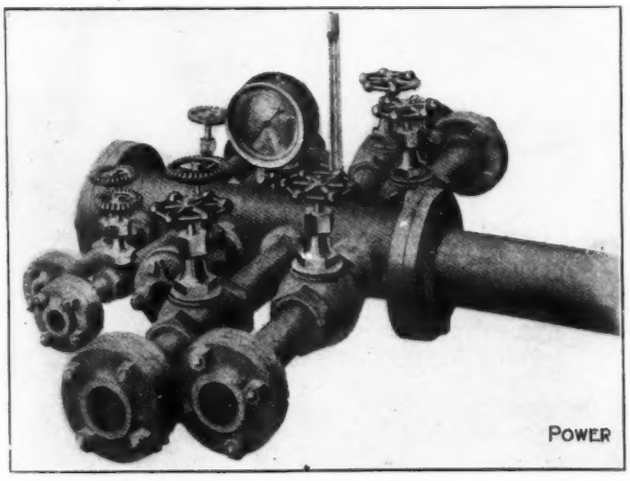


FIG. 1. FOR MEASURING FLOW OF AIR THROUGH ORIFICES

passing through the orifice. This coefficient, which depends upon the shape of the orifice, can be accurately determined only by experiment, but averages 0.942.

A rather elaborate series of experiments to ascertain the coefficient of discharge of air under various conditions was conducted several years ago by Sanford A. Moss and the results of his research are explicitly discussed in the *American Machinist*, Aug. 10, 1905; Sept. 20 and 27, 1906.

(2) Recommendation is made by Mr. Lancaster that the orifice manifold be connected to the discharge opening of the compressor. Such a method is obviously incorrect, for the pulsations in the pipe due to the intermittent discharge of air from the compressor causes disturbances and pressure fluctuations which prevent the attainment of that accuracy in air measurement which is so desirable. Tests conducted on large compressors furnishing air for the construction of the aqueduct in New York City showed such pressure variations that the results obtained were of value only for comparison with those obtained on other machines operating under similar conditions.

(3) The arrangement of the battery of orifices, as illustrated by Fig. 1, also shows a departure from the basic principles underlying and governing the design of orifices for accurately measuring the flow of air, and consequently makes the exact value of the coefficient of discharge still more uncertain.

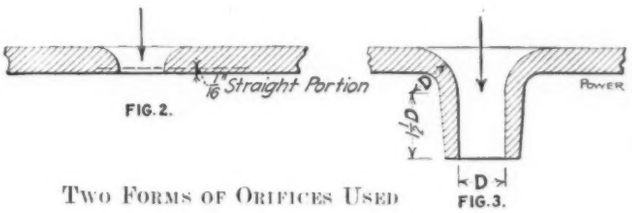


FIG. 2. TWO FORMS OF ORIFICES USED FIG. 3.

The formula given is based on the condition that the air enters the orifice at a velocity so low when compared with the discharge velocity as to be negligible; also, that the flow to the orifice is direct and not disturbed by constricted passages or sudden changes in direction with their resulting eddies. If these conditions do not prevail a correction must be made. The illustration shows the sharp turns necessarily made by the air in leaving the body of the manifold; also the globe valves, which are so close to the orifices as to make their effect on the discharge most pronounced. These valves are a necessity, but the eddies which they produce can be almost entirely overcome by considerably increasing the size of pipes in front of the orifices. This procedure would also decrease the air velocity to the orifices which, as already noted, has an important bearing on the accuracy of the results obtained. The manifold proper should be many times larger than shown and connected, not to the discharge line of the compressor, but to a receiver of ample capacity to minimize the effects due to a pulsating discharge. Pressure should be recorded, not in such a tank or in the manifold, but directly in front of each orifice used in the test.

(4) While the theoretical formula for flow furnished by the science of thermodynamics has no relation to the shape of the orifices employed, the form does affect the coefficient of discharge and should receive consideration. The shape used by Mr. Lancaster, reproduced in Fig. 2, has not been generally accepted by air-compressor builders, a more common form being as shown in Fig. 3. Here the length of the straight portion is one and one half times the diameter, with an inside radius equal to the diameter.

(5) Mr. Lancaster mentions the desirability of recording the temperature of both the air and the cooling water when entering and leaving the intercooler, but he fails to show the possible application of such readings to correct the apparent volumetric efficiency given by the formula already discussed. Efficiency of intercooling and humidity of the inlet air should always be considered, however, the affinity of air at high temperature for water vapor being concisely illustrated by Frank Richards and A. Hoffman in recent issues of POWER. Bearing this fact in mind, it is easy to conceive of a compressor producing perfect intercooling, showing by actual test a lower volumetric efficiency than a compressor in which an inefficient intercooler allows an excess of water vapor to be carried to the high-pressure cylinder and consequently through the orifice. Power consumption per unit quantity of air delivered indicates to the discriminating purchaser, however, which is the best machine and shows that the measure of volumetric efficiency alone is not the criterion by which a compressor should be judged.

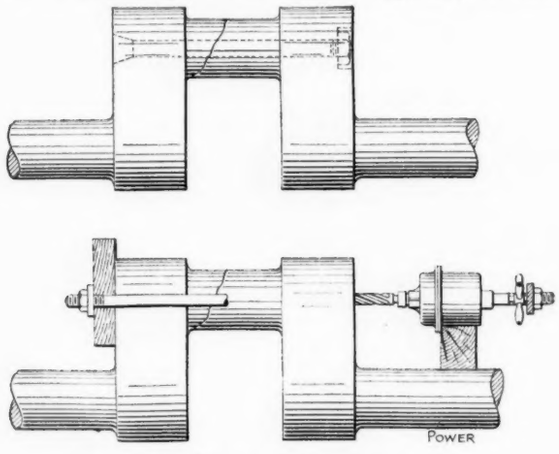
That the overall efficiency of the outfit considered by Mr. Lancaster in his summary of test results was very low when compared with present-day types of direct motor-driven compressors, is evident, when, even if we neglect the effects of humidity and apply only a coefficient of discharge of 0.942 (although the form of the orifice battery indicates a lower value) it is noted that the horsepower input to the motor per 100 cu.ft. of free air delivered at 100 lb. gage pressure equals 24.15. Compared with 15.31, the theoretical horsepower required for two-stage compression, this shows a total efficiency of compression of 63 per cent.

H. L. DEAN.

Brooklyn, N. Y.

Broken Crankpin Repaired

The illustration shows the way we repaired a broken crankpin on a 120-ton ice machine. The pin diameter was 9 in. and the pin was broken diagonally as shown.



AIR DRILL IN POSITION

It had run hot for several days, but no unusual noise indicated that it was broken. On disconnecting, we found the trouble.

To make a quick repair, we blocked and clamped an air-drill square with the crank. Two extension drills were made, the hole being started with the ¾-in. and the 2-in. was run through afterward. A taper reamer corresponding to the head of the bolt was used on one end of the pin and a flat cutter on the other end to recess for the head and nut to come flush with the crank web, as there was but little clearance in the crank case. After the bolt was put in and the pin drawn together a V-shaped groove was chiseled around the pin, following the crack. Since making this repair the engine has run continually for over a month making 44 r.p.m. and running perfectly cool.

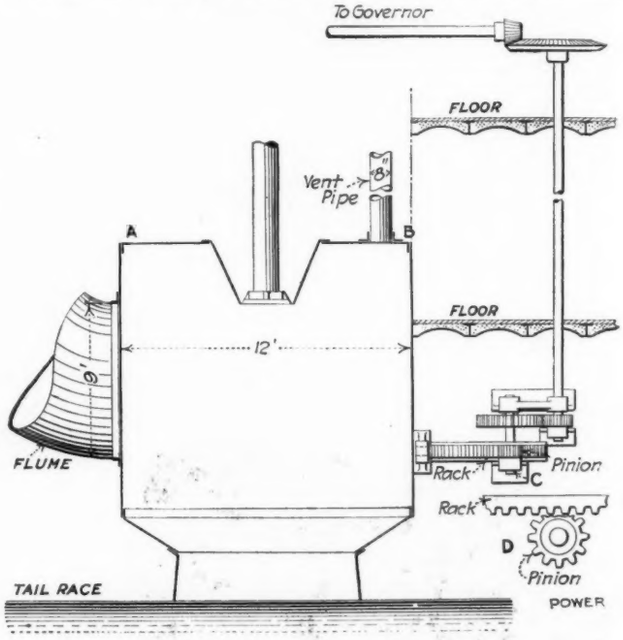
The job required two men 60 hours; 24 hours at double time and 36 hours at single time, and the total cost, including drills, reamers, etc. was $147.

J. H. CUNNINGHAM.

Toledo, Ohio.

Waterwheel Accident

Last winter, in a mill where there are two 51-in. waterwheels under a 17-ft. fall, one of the wheels gave trouble which at first looked like a mystery. There was a loud report, and half the top of the waterwheel casing lifted off, breaking at point *A* and allowing the water to flood the wheel-pit floor. The head gates were closed



BROKEN PINION CAUSED WATER-HAMMER

and things were looked over, but nothing was found to which the cause could be attributed.

A man sent from the shop where the wheels were built could throw no light on the subject, as he had never seen anything like it before. The general manager sent for a master mechanic with extensive experience with waterwheels, who said our trouble was caused by air being pocketed under the head. We put in an 8-in. pipe as shown at *B* for a vent. After running a while, the following day, bang went the head again. This time it was found that at some previous time several teeth had been broken out of the rack pinion *C*. In operating the gate when the pinion got to the position shown at *D*, there was nothing to prevent the gate from closing quickly. This, of course, produced a water-hammer, and something had to let go. A new pinion was put on and castings made to fit over the crack in the

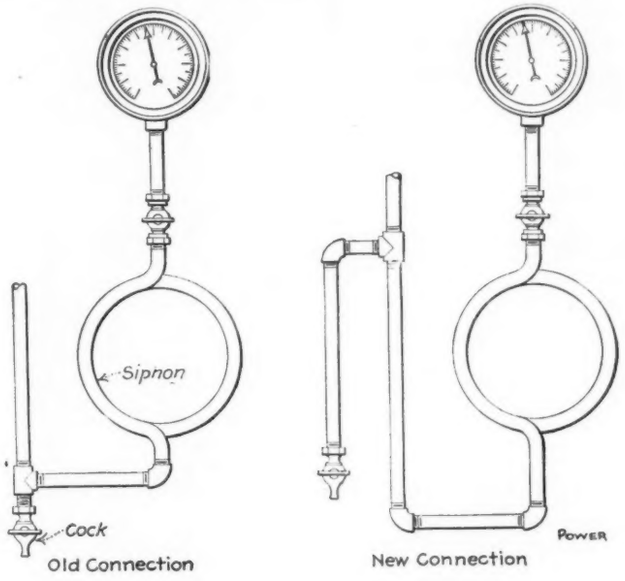
head were secured with ½-in. capscrews. Since then we have had no such trouble.

THOMAS SHEEHAN.

Williamstown, Mass.

Steam-Gage Connections

In one plant the engineers frequently blew the water out of the steam-gage connections, and as the steam came in direct contact with the tubes, it distorted them and the gages read incorrectly. A lecture on steam gages helped the matter somewhat, but now and then someone would drain the lines again.



PROTECTING THE GAGE

I had all the gage connections changed as shown, so that no harm could be done. The steam fitter made all the changes one Sunday while the plant was shut down. I kept watch for a week, but I never saw a single drain cock opened, much to my chagrin, as the steam fitter had wagered the cigars that after making the change not one of the cocks would be opened in a week, and he was right. I have often wondered why.

C. E. ANDERSON.

Chicago, Ill.

Diagrams from New Engines

Diagram Fig. 1 is from one of the best known high-speed Corliss type, four-valve engines, which has only been in service one month. The piston speed is 720 ft. per minute at 180 r.p.m., the stroke being 24 in. While this

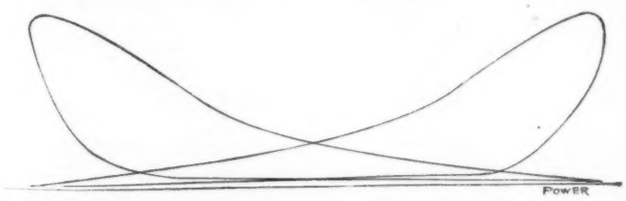


FIG. 1. INSUFFICIENT VALVE TRAVEL

is good piston speed for economy, this diagram shows poor steam distribution, the admission is late and the steam is wire-drawn considerably, as is clearly evident.

It is clear that the movement of the valve is too slight for the required steam and small movement means poor wearing qualities.

Diagram Fig. 2 is from a four-valve Corliss type engine, controlled by a variable eccentric. The piston speed is

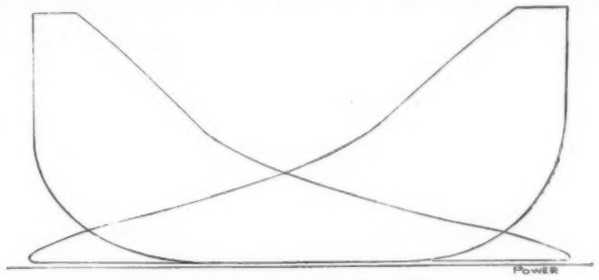


FIG. 2. SUPERIOR VALVE MOTION

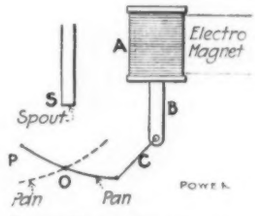
690 ft. per min. at 230 r.p.m., the stroke being 18 in. This engine has an advantage in that the piston speed is considerably lower and the valve motion is far superior. These diagrams show the operation of the engines as turned over by the erecting man.

C. R. MCGAHEY.

Baltimore, Md.

Alternating-Current Magnet Burnouts

The steady current that a given direct voltage will maintain through a solenoid depends upon the resistance of the winding irrespectively of whether the latter includes an iron core or not. The current that an equivalent alternating voltage will maintain through the solenoid depends upon the impedance of the coil, which in turn depends not only upon the resistance of the winding, but upon whether the winding includes a magnetic circuit, and, if it does, upon whether the iron of the magnetic circuit is continuous or is broken by an air gap. It follows, then:



PAN CONTROLLED BY ELECTROMAGNET

(1) If to a coil designed for use with an iron core, rated alternating electromotive force, be applied without the core, the coil will burn out because the current will be abnormal.

(2) If to a solenoid designed to operate with a core air gap of a certain maximum thickness, rated alternating voltage be applied continuously or too continually, the coil will be burned out; how long it will last under these conditions will depend upon how often or how continuously the electromotive force is applied.

Therefore, a contactor operated by an alternating current will take a much heavier current when it is open than when closed. These possible conditions of abuse are illustrated by the following:

An operator burned out a brake coil of an electrically operated hoist. He wound a new one to replace it, but this coil and several others that he wound were burned out by the test he gave them to insure that they were all right before installing them. He finally became tired

of winding coils and sent for assistance, whereupon it was found that the preliminary test consisted in applying full rated voltage to each coil as it lay on the table without any magnetic circuit to take the place of the one that it would have had when installed on the crane. Had the operator included an ammeter in his test circuit, the current would have surprised him, and the ammeter, too, probably, unless he had happened to get one that was big enough.

In the accompanying diagram, *S* is a spout to deliver purifying liquid to the water delivered by a motor-driven filter outfit; *P* is a tin pan pivoted at *O* so that the pan may take either of the positions indicated. When the plunger *B* of the electromagnet *A* is down, the pan is in the position represented by the full line, and when *B* is up, the pan is in the dotted position. Magnet *A* was so connected that when the motor started, *A* would be energized, and the pulling up of *B* would tilt the pan to the dotted position, thereby deflecting the purifier into the proper intake. Stopping of the motor would simultaneously deënergize the magnet and permit gravity to restore all parts to the release position in which the purifier was deflected to a receptacle on the opposite side.

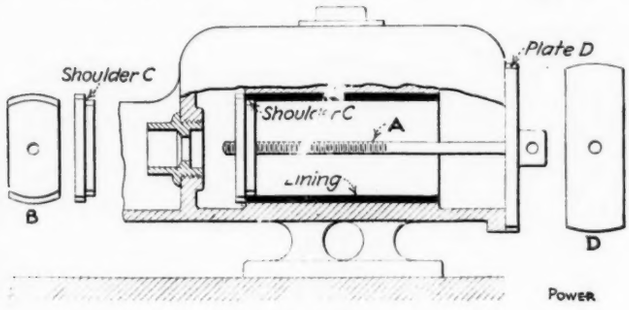
The operator had had several magnet coils burn out and he thought that the cause was high voltage. Investigation proved that the trouble was due to a rigid connection between rod *C* and the pan. This caused *B* to bind at the lower end of its travel, and the coil had not sufficient strength to release it. Under this condition, the coil had practically no core within it, hence the abnormal current taken burned it out. Insertion of a piece of light chain between the rod *C* and the pan *P* stopped the trouble.

J. A. Horton.

Schenectady, N. Y.

Removing Pump Linings

The illustration shows how I have several times removed the worn lining from the water end of a pump. The heavy bolt *A* is threaded for a considerable length.



Parts Assembled

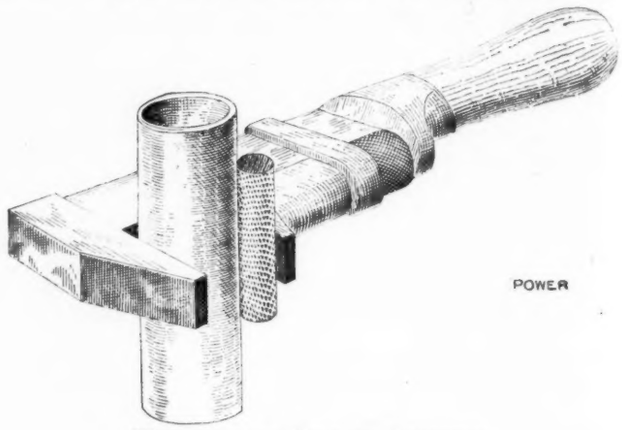
Plate *B* is drilled and tapped to match. Shoulder *C* is an easy fit into the lining and the ends of the plate just clear the bore of the cast-iron body. Plate *D* is used to take the strain on the bolt at the head. After assembling as shown, the lining may be pulled as far as plate *D*, when it becomes necessary to put in blocking between the plate and the pump. This same rig may be used to pull in the new lining by reversing, but care should be taken to protect the stuffing-box in so doing.

George J. Little.

Passaic, N. J.

Improvised Pipe Wrench

An old trick worth knowing is illustrated. A short piece of a round file and a monkey-wrench may be used to turn a pipe, in the absence of anything better. The



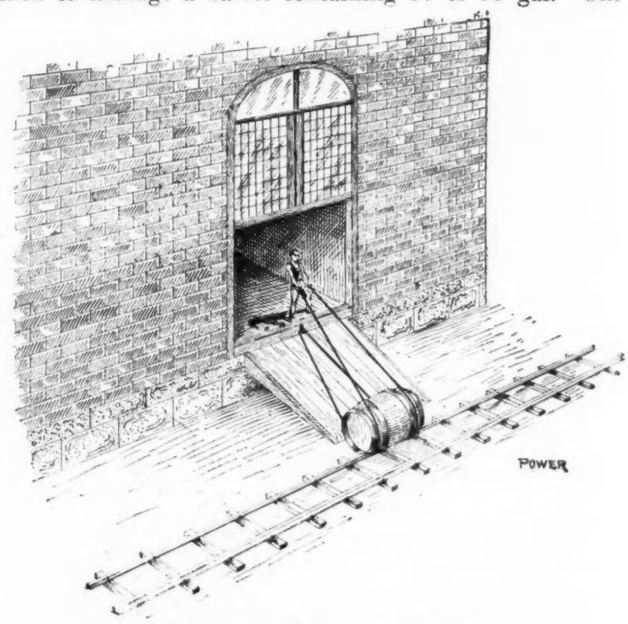
Wrench and File in Position

wrench is opened enough to span the pipe and the file put in parallel to the pipe, as shown. When pressure is applied to the wrench the file rolls in firmly between the wrench jaw and pipe, causing a grip which holds without the least slippage. A slight backward movement will release the wrench instantly.

Whitinsville, Mass. A. C. Nella.

Rolling Barrels up an Incline

The illustration shows the incline up which barrels of oil had to be rolled at our plant. It took two husky men to manage a barrel containing 50 to 55 gal. One



A Hitch to Roll the Barrel

of the oilers finally drove a hook into the door sill, out of the way. Then, taking a long rope, he doubled it and hooked it to the door sill and passed it around under the barrel near each end, and back to the doorway, as shown. The barrel could then be guided and pulled up the incline easily by one man.

Kittanning, Penn. R. G. Curren, Jr.

Inquiries of General Interest

Rectifier in an Absorption System. What is the office of the rectifier in an absorption system of refrigeration?

C. R. H.

To condense any water vapor carried along with the ammonia vapor from the generator, the liquid thus condensed being drained off or returned to the generator.

Opening Glass Gage Connections—In opening the connections for a water-gage glass to a boiler after they have been turned off, why should the lower valve be opened first?

R. G. M.

Opening the lower valve first would warm up the gage-glass more gradually than to turn the steam in first and thereby be less likely to cause the glass to break.

Advantage of Independently Driven Air Pump—What is the advantage of an independent air pump?

E. M.

For large powers, an independently driven air pump has an advantage over a direct-connected pump in requiring less power at reduced engine loads, as the speed of the air pump is under separate control to suit the requirements of the condenser.

Bleeder Turbine—What is a bleeder turbine?

H. D. R.

A steam turbine which is adapted to be bled at one of the intermediate stages, steam being taken from it as is often done from the receiver of a compound engine for heating or industrial purposes.

Replacing Tube in Water-tube Boiler—If a tube in the center of the middle header of a B. & W. type water-tube boiler should explode, would it be necessary to remove other tubes in order to remove and replace the damaged tube?

H. A. L.

No, for opposite each tube end in the headers is a hand-hole of sufficient size for cleaning and removing or renewing a tube without disturbing other tubes.

The Half-Stroke Which Requires Less Time—In which end of the cylinder of a reciprocating engine is one-half of the stroke of the piston accomplished in the least time?

M. D.

Less than one-quarter of the revolution of the crank is performed by one-half stroke on the head end so that with uniform rotation less time is required for accomplishing one-half stroke of the piston in that end of the cylinder.

Performance of Condensers—What are the leading factors upon which it is usual to base the performance of condensers?

J. E. B.

The performance is based on the number of inches of vacuum to be obtained when condensing, per hour, a stated weight of steam of given temperature, and handling, during the same period, a given quantity of condensing water supplied at a stated temperature.

Steam Liberating Surface per Boiler Horsepower—What should be the steam liberating surface in boilers per horsepower?

H. J. M.

With ordinary good circulation, about ¾ sq.ft. of steam-liberating surface per boiler horsepower is satisfactory for the generation of dry steam in fire-tube boilers, and about ⅜ sq.ft. of steam-liberating surface per horsepower has given good results in water-tube boilers having steam drums which are not subjected to the greatest intensity of the fire.

Gage Cock Shows Steam—When all water column connections of ample size are clear and the water glass shows three gages of water, what would cause the gage cocks to show only two gages of water in a boiler?

S. J. A.

With high boiler pressure and water only a little above the third gage cock, the discharge of water from the gage cock at high velocity would be broken up into a fine spray which could easily be mistaken for steam. The uncertainty is one of the principal reasons for placing greater reliance on a glass gage.

Legal Decision Reports—Under "Recent Court Decisions, there are references to publications evidently containing fuller reports of the cases. Where can these be obtained?

K. L. W.

The publications referred to are the various weekly Reporters covering the United States, as follows: Atlantic, Pacific, Federal, Northeastern, Northwestern, Southeastern, Southwestern, Southern and Supreme Court Reporter (semi-monthly) and the New York Supplement. These belong to the National Reporter System and are published by the West Publishing Co., 50 West Third St., St. Paul, Minn. Copies can be obtained direct from the publisher or from any dealer in law books, or can be consulted in any law library.

Neglecting Area of Piston Rod—In figuring from indicator diagrams the horsepower developed by an engine, what is the usual error of computation resulting from neglecting the reduction of piston area by the cross-sectional area of the piston rod?

M. G.

The average size of piston rods of steam engines is about ⅓ the diameter of the piston, thereby reducing the effective area of the piston about $^1/_{36}$, or about 2.8 per cent. As for engines without tail rods, this reduction would apply only to the crank side of the piston, then, with the same mean effective pressure indicated in each end of the cylinder, neglecting the correction for the cross-sectional area of the piston rod would make the computation result about 1.4 per cent. too large.

Terminal Pressure with ¼ Cutoff—With initial pressure at 100-lb. gage pressure and 5 per cent. clearance, what would be the terminal pressure with cutoff at 25 per cent. of the stroke, assuming isothermal expansion

H. H.

Gage pressure of 100 lb. per sq.in. would be equivalent to

$$100 + 14.7 = 114.7 \text{ lb. absolute}$$

With 5 per cent. clearance and cutoff at 25 per cent. of the stroke, the volume of steam present at the time of cutting off would be 5 + 25 or 30 per cent. of the piston displacement, and the total volume after expansion would be 100 + 5 or 105 per cent. of the piston displacement. As the terminal pressure would be inversely as the volumes before and after expansion, then the terminal pressure would be

$$\frac{30}{105} \times 114.7 = 32.77 \text{ lb. absolute,}$$

or

$$32.77 - 14.7 = 18.07 \text{ lb. gage pressure.}$$

Boiler Efficiency—What is the efficiency of a boiler and how is it determined?

T. B.

There are two methods of defining and estimating the efficiency of a boiler, one being based on combustible and the other being based on coal. According to the first,

$$\text{Efficiency of a boiler} = \frac{\text{Heat absorbed per lb. of combustible}}{\text{Calorific value of 1 lb. of combustible}}$$

This is the standard of comparison for all tests, and is the one which is understood to be referred to when "efficiency" alone is used without qualifications. The "heat absorbed per pound of combustible" is to be calculated by multiplying the equivalent evaporation from and at 212 deg. F. per pound of combustible by 970.4 and the calorific value of 1 lb. of the combustible is to be determined by a coal calorimeter or estimated from the analysis of the coal.

When the purpose is to include boiler and grate together

$$\text{Efficiency of the boiler and grate} = \frac{\text{Heat absorbed per lb. of coal}}{\text{Calorific value of 1 lb. of coal.}}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Elementary Mechanics--XXVII

Last Lesson's Answers

121. The time of flight is found from equation (70), where $T_1 = \frac{2V \sin a}{g}$. In this case the angle a = 45 deg. and $\sin a = 0.707$; also $V = 1200$ ft. per sec., hence $T_1 = \frac{2 \times 1200 \times 0.707}{32.16} = 52.8$ *sec.*

122. The projectile will strike the ground at a distance from the gun equal to the horizontal range R, which is determined from equation (71), where $R = V \cos a \times T_1$; hence
$R = 1200 \times 0.707 \times 52.8 = 44{,}795$ *ft.*, or 8.48 *miles.*

123. From equation (73), $H = \frac{V^2 \sin^2 a}{2g}$. In this problem $V = 1200$ ft. per sec.; $\sin a = 0.707$, hence
$H = \frac{1200 \times 1200 \times 0.707 \times 0.707}{2 \times 32.16} = 11{,}190$ *ft. or* 2.12 *miles*

124. The range is easiest determined by first solving problem 125, to ascertain the time of flight. From equation (75), $-H = V \sin a \times T - \frac{1}{2} g \times T^2$, where H is the elevation of the point of projection and in this case is equal to 500 ft. Substituting the given values in equation (75) there results, $-500 = 1200 \times 0.707 \times T - 16.08\, T^2$ or, $T^2 - 52.76\, T = 31.09$, which is a quadratic equation and may be solved by adding 695.9 to both sides of the equation, so as to make the left side a perfect square, thus,

$T^2 - 52.76\, T + 695.9 = 31.09 + 695.9 = 727$

and taking the square root of both sides, there results,

$$T - 26.38 = 26.96$$

or,
$$T = 26.96 + 26.38 = 53.3 \text{ sec.}$$

The range is dependent upon the horizontal component of the velocity and the time of flight, or, as given by equation (71), $R = V \cos a \times T_1$; where V = 1200 ft. per sec., and $T_1 = 53.3$ sec., therefore
$R = 1200 \times 0.707 \times 53.3 = 45{,}220$ *ft.*, or 8.58 *miles.*

125. In problem 124 the total time of flight was found to be 53.3 sec., which, it will be noted, is just about one-half second longer than the time found in problem 121.

Rotary Motion

In equation (47), it was shown that the force required to produce an acceleration of a feet per second per second on a mass of M pounds was equal to $M \times a$. As the mass becomes greater the force required to produce a given acceleration also becomes greater; that is, the force is directly proportional to the mass, *assuming that the mass is moving in a straight line.*

In the case of rotating bodies, not only must the mass be considered, but also its distance from the center of rotation. Thus a small force acting at a great distance from the center of rotation may produce the same "torque" or turning moment as a large force acting at a small distance. The resistance to rotation of a given body, then, depends both on the mass of the body and the distribution of the mass relative to the center of rotation. It is evident from experience that it is much easier to set in motion a flywheel whose mass is concentrated in its hub than it is to set in motion one whose mass is concentrated in its rim. Moreover, it must be apparent that the linear acceleration of a given mass is also dependent upon its distance from the center of rotation. Thus, if two wheels of the same mass, but of different diameters, are to be brought up to speed in the same

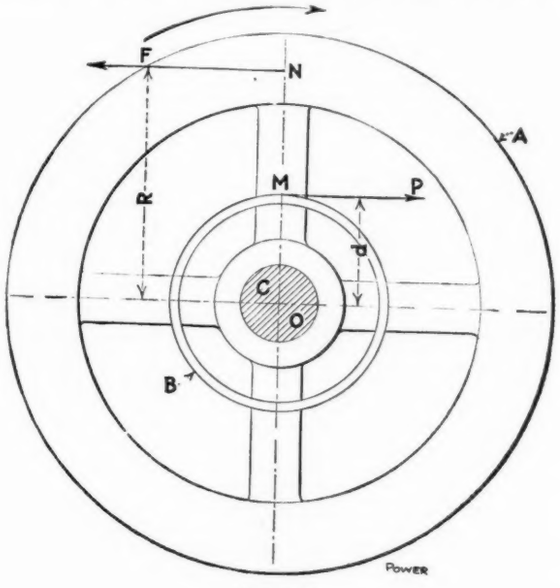


Fig. 79.

time, the linear accelerations of their rims must be different in order to produce the same angular acceleration.

In equation (26) it was shown that the angular velocity of a body, expressed in radians, was equal to the linear velocity divided by the radius. In like manner it may be shown that the angular acceleration in radians is equal to the linear acceleration in feet per second per second, divided by the radius in feet. Thus, let

a = The linear acceleration in feet per second per second;
a_1 = The angular acceleration in radians per second per second, and
R = The radius of rotation in feet, then,

$$a_1 = \frac{a}{R} \text{ or, } a = a_1 \times R$$

As a general rule, the acceleration of rotating bodies is expressed in revolutions per second per second, and as there are 2π radians in the circumference of a circle (see lesson XV), it follows that $a = 2\pi AR$, where A = the increase in revolutions per second per second. In the case of a flywheel, each separate particle will be located at a fixed distance from the center of rotation

and, as there is an infinite number of particles, there will be an infinite number of radii and each particle will have a different linear velocity. For this reason the mass of the wheel is assumed concentrated at a certain point, so that the resistance which the wheel would offer to a change of angular velocity will remain the same. The distance from this point to the center of rotation is called the *radius of gyration* of the wheel. The value of the radius of gyration of various sections may be found by reference to any engineers' handbook. In the case of flywheels with heavy rims the hub and arms are neglected and the weight of the rim only is considered. In such cases, it is customary to consider the radius of gyration as the distance from the center of the wheel to the middle of the rim.

In Fig. 79, assume a heavy wheel A to be mounted on the shaft C, to which is keyed the pulley B. A force of P pounds is applied at the rim of the pulley. It is desired to find the value of this force in terms of the weight of the wheel in order to give a definite angular acceleration to the wheel. First assume that the mass M of the wheel is concentrated at the center of the rim at a distance of R feet from the center of the shaft. It must be evident that the inertia of the rim will act in a direction opposite to that in which the wheel is to move.

Let F = the force of inertia which, from equation (47), is equal to the mass of the rim times the linear acceleration, or $F = M \times a$. Now from the conditions of equilibrium, the algebraic sum of the moments about the point O must equal zero. Thus, $F \times R = P \times d$, and as $F = M \times a$, it follows that, $M \times a \times R = P \times d$. Also as previously proven, the linear acceleration a is equal to $2\pi A \times R$; therefore, substituting this value in the above equation, there results,

$$M \times 2\pi \times A \times R \times R = P \times d, \text{ or,}$$
$$2\pi \times MR^2 \times A = P \times d \qquad (76)$$

Expressed in gravitational units, the equation becomes,

$$2\pi \times \frac{W}{g} \times R^2 \times A = P \times d \qquad (77)$$

where,

W = The weight of the rim in pounds;
R = The radius of gyration in feet;
A = The angular acceleration in revolutions per second per second;
P = The force required in pounds;
d = The moment arm in feet of the force P, and
g = Acceleration due to gravity = 32.16.

The quantity MR^2 is called the moment of inertia of the body. To determine this quantity, it is necessary to consider the body as being made up of an infinite number of small particles, and to multiply each of these particles by the square of its distance from the center of rotation, and then add all these small quantities together, which sum gives the moment of inertia.

The moment of inertia of bodies of uniform density may be determined by the aid of calculus, which is beyond the scope of this work. However, these values may be found by reference to handbooks.

In the design of flywheels, it is desired to have as large an inertia effect as possible with a given weight. For this reason the moment of inertia is made large by placing most of the metal in the rim and making the diameter of the wheel relatively large. The moment of inertia of the hub and the arms is comparatively small, and, therefore, in the following problems only the inertia effect of the rim will be considered.

Study Questions

126. The point N on the wheel A, Fig. 79, is 5 ft. from the center of the shaft. The wheel starts from rest and at the end of 2 min. is running at 75 r.p.m. Find the linear acceleration of the point N in feet per second per second.

127 (a) Find the angular acceleration of the point N in revolutions per second per second. (b) Do all points in the wheel have the same angular acceleration?

128 The outside diameter of a cast-iron flywheel is 12 ft. The rim is 8 in. thick and the face of the wheel is 10 in. Find the weight of the rim and its radius of gyration.

129. What force P, acting at a distance of 2 ft. from the center of the wheel, will be required to bring the wheel up to a speed of 90 r.p.m. in 1½ min. Neglect the weight of the hub and the arms.

130. Assume the wheel running at 120 r.p.m. What braking force P, acting at a distance of 18 in. from the center of the shaft, will be required to reduce the speed to 60 revolutions in one minute?

Operation of Boiler-Inspection Laws

By A. L. H. Street*

SYNOPSIS—A review of court decisions in which the scope of inspection regulations has been considered.

In view of the movement toward the establishment of uniform boiler-inspection laws throughout the several states, it is interesting to note the points related to such legislation which have been before the appellate courts of the country.

The relationship between state and federal jurisdiction was involved in a prosecution which was brought by the Commonwealth of Massachusetts against the Breakwater Co., 100 *Northeastern Reporter*, 1034. In reversing a conviction of the company for a claimed violation of the Massachusetts inspection laws, the Supreme Judicial Court of that state decided the following points:

The provision of the law for the inspection of "all steam boilers, and their appurtenances except . . . boilers under the jurisdiction of the United States" does not exclude from the operation of the statute everything over which the United States, by the fullest exercise of its powers under the constitution, might assume authority. "There is an extensive field of human activity over which the states may exercise jurisdiction, until the United States through Congress asserts its power."

Such a law as this must not be given a narrow interpretation, since it relates to the "safety of large numbers of people and considerable amounts of property."

Boilers on seagoing barges are not subject to the state inspection law, but, in the absence of regulation by the United States, a provision of a state law such as that above quoted extends to a boiler on a barge used solely for loading and unloading cargoes, and not for purposes of propulsion. Giving the law this interpretation does not make it invalid as an interference with interstate

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or foreign commerce. "The general purpose of the statute is so humane that it cannot be held to be an imposition upon navigation."

Accordingly, the Supreme Judicial Court decided that the question whether the Breakwater Co. had violated the law by failing to have the boiler on its barge inspected depended upon whether the barge was a seagoing one.

The principle that a boiler must be permanently located within the jurisdiction which attempts to regulate it finds support by analogy in the case of People vs. Prillen, 65 *Northeastern Reporter,* 947. In that case the New York Court of Appeals reversed a conviction of defendant on a charge of operating two boilers without having obtained the certificate of qualification required by the New York City charter. It appeared that the boilers were operated on a scow by a New Jersey company within the limits of New York City in removing an obstruction from the East River. The Court of Appeals, referring to the charter provision, said: "This section evidently contemplates the inspection of such steam boilers as are permanently in use in the city of New York."

By decision of the Minnesota Supreme Court in the case of State vs. Justus, 94 *Minnesota Reports,* 207, the Minnesota inspection law has been held not to extend to the boilers of steam-heating plants in private buildings. The court said:

"The act was designed for the better protection of life and property by providing for the inspection of steam vessels and steam boilers used to generate power for the operation of machinery, and requiring that all persons having charge of the operation of the same and masters and pilots of steamboats on inland water of the state be competent and qualified for the service."

Boiler Laws and Their Application to the Manufacture of Stock Boilers

By G. G. Dana, M. E.

SYNOPSIS—Comments on existing boiler laws and rules from the viewpoint of the manufacturer, and suggestions tending toward the standardization of design and construction.

Safety is the basis for many reforms and to this end boiler laws have been or are being enacted by several states and cities as well as several of the Canadian provinces. Laws of this kind are justified, but there should be enough scope to meet the various conditions, and they should not unnecessarily hamper.

Massachusetts and Ohio have laws almost identical in their application, although the arrangement of subjects is more systematic in the Ohio rules.

The rules of Detroit, Mich., and Manila, P. I., are patterned after the Massachusetts rules.

The Canadian provinces of Alberta, Ontario and Saskatchewan have boiler laws which are practically alike, but differ widely in many respects from those of Massachusetts and Ohio.

To avoid repetitions in what follows, the Ohio rules will be mentioned when they are the same as those of Massachusetts, Detroit and Manila, and Alberta, where they are the same as Ontario and Saskatchewan; separate mention being made on subjects where differences occur in the rules.

Most of the laws are good individually and a boiler constructed in compliance with any one of them would be safe and durable, but it is difficult to build stock boilers which will meet the requirements of all of them.

The article on "A Comparison of Boiler Standards" by Mr. MacDonald in Power, May 19 issue, has covered many items, but there are some other points.

Under stamping and identification, the firm's serial number must be stamped on all Massachusetts standard boilers. I have been given to understand by the chairman of the Board of Boiler Rules in Boston that this number must be in a separate series, which shall start with one and shall comprise only the boilers built Massachusetts standard. This requirement makes it necessary for the manufacturer to keep track of each boiler under two numbers, making an extra amount of clerical work with the records.

This is all right for boilers built to order, but for stock boilers it means that each one built must be stamped and a report filled out and sent to each state to which there is a probability of the boiler being shipped.

The Canadian rules require that only boilers actually shipped into the province shall have an affidavit of manufacture sent with the boiler. The Ohio and Massachusetts rules should be modified to require that manufacturers keep an accurate record of all materials used in each boiler while the boiler is being built; then from this record the data report could be filled out and the boiler stamped, under the authority of the inspector, after the destination of the boiler is known. This would eliminate much cumbersome procedure, and also reduce the files of the Board to the actual number of boilers shipped into the state.

Materials

A comparison of the kind of material can best be made by referring to Table 1.

Only the Ohio and Massachusetts rules specify the brand of steel: the Canadian rules lay more stress on the physical and chemical properties.

Shells, etc., by the Ohio rules must be of firebox steel, while Alberta allows the class which is known to the trade as flange steel. In Ohio stayed surfaces may be of any grade of openhearth steel, while Alberta requires them to be the same as shells unless they are exposed to the fire, in which case, they must be firebox steel. Fireboxes and combustion chambers may be of any of these three brands of steel in Ohio.

The per cent. of elongation in 8 in. should be allowed to vary as by the Saskatchewan rules, being determined by dividing 1,450,000 by the tensile strength, so that as the tensile strength increases, the ductility de-

creases which is a natural result with most kinds of steel. This sliding-scale method is used by the American Society for Testing Materials, as being equitable to purchaser and manufacturer. The minimum amount of phosphorus is allowed to be higher when the steel is made by the acid process than when the basic process is used. It is claimed that the acid process makes a better quality of steel, but that it is difficult to keep the phosphorus content down as low as may be done with the basic process.

TABLE I. GIVING COMPARISONS OF THE KIND OF MATERIALS REQUIRED FOR THE PARTS OF A BOILER BY THE VARIOUS RULES

Part of Boiler	Properties Considered	Ohio & Massachusetts	Alberta & Ontario	Saskatchewan	British Columbia
Shells, domes, drums and butt straps.	Brand	Fire-box steel	.....	.....	.....
	Tensile strength, lb. per sq.in.	52,000 to 62,000	55,000 to 65,000	55,000 to 65,000	55,000 to 72,000
	Elongation in 8" not less than	26%	22%	*26% to 22%	20%
	Phosphorous shall not exceed	0.03%	0.04%	Basic .04, acid .05%	0.04%
	Sulphur shall not exceed	0.04%	0.04%	0.05%	0.04%
	Manganese	0.30% to 0.60%	.....	.....	.....
Heads or any plates requiring staying or flanging.	Brand	Flange, fire box or ex. soft			.....
	Tensile strength, lb. per sq.in.	45,000 to 65,000			55,000 to 67,000
	Elongation in 8" not less than	25, 26, or 28%	May be the same as for shell	May be the same as for shell	23%
	Phosphorous shall not exceed	0.04, 0.03, or 0.04%			.....
	Sulphur shall not exceed	0.05, 0.04, or 0.04%			.....
	Manganese	.30 to .60%; .30 to .50%			.....
Fire-box or combustion chamber.	Tensile strength, lb. per sq.in.	May be the same as for heads	52,000 to 62,000	52,000 to 62,000	55,000 to 65,000
	Elongation in 8" not less than		26%	*28 to 23.4%	25%
	Phosphorus shall not exceed		0.035%	Basic .035, acid .04%	.....
	Sulphur shall not exceed		0.035%	0.04%	.....
Rivets.	Brand	Extra soft	.....	.....	.....
	Tensile strength, lb. per sq.in.	45,000 to 55,000	45,000 to 55,000	45,000 to 55,000	55,000 to 65,000
	Elongation in 8" not less than	28%	28%	28%	25%
	Phosphorous and sulphur not to exceed	0.04%	0.04%	.045%	.....
Stay bolts, through stays and braces. Weldless steel.	Tensile strength, lb. per sq.in.	62,000 maximum (certified)	52,000 to 62,000	52,000 to 62,000	55,000 minimum
	Elastic limit, lb. per sq.in.	† Not less than ½ T.S.	33,000 maximum	33,000 maximum	33,000 maximum
	Elongation in 8" not less than	28%	25%	25%	22 to 25%
Stay bolts, through stays and braces. Weldless iron.	Tensile strength, lb. per sq.in.	.....	46,000 minimum	46,000 minimum	46,000 minimum
	Elastic limit, lb. per sq.in.	†	26,000 minimum	26,000 minimum	26,000 minimum
	Elongation in 8" not less than	.....	22%	22%	20 to 22%

*By the Saskatchewan rules the elongation per cent. in 8" may vary inversely as the strength of the material, being determined by dividing 1,450,000 by the tensile strength $\left(\frac{1,450,000}{\text{T. S.}}\right)$ and the phosphorous contained in the steel may have a higher percentage when made by the acid process than when the basic process is used.

†Ohio and Massachusetts rules do not give any requirements for stay bolt material, either iron or steel. When a certified report of the material accompanies the data report the qualities shall be as given in this table.

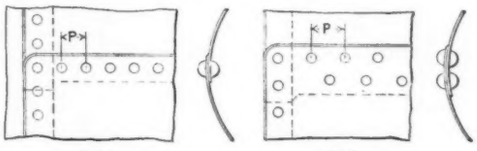


FIG. 1 LAP JOINT - SINGLE RIVET

FIG. 2 LAP JOINT - DOUBLE RIVETS

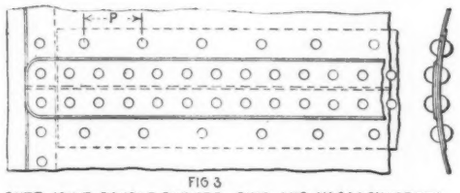


FIG 3 BUTT JOINT - DOUBLE RIVETED - OHIO AND MASSACHUSETTS

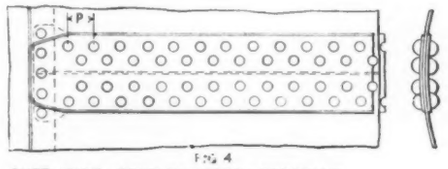


FIG 4 BUTT JOINT - DOUBLE RIVETED - CANADIAN

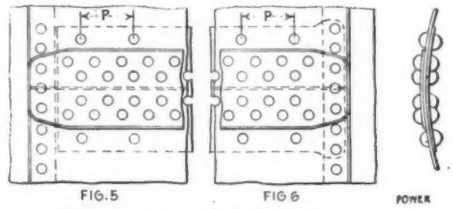


FIG. 5 FIG 6 POWER

BUTT JOINT - TRIPLE RIVETED
OHIO & MASSACHUSETTS CANADIAN

PLATE I. RIVETED JOINTS

The longitudinal seam is a subject of disagreement among the various rules. Ohio requires the butt joint, Plate I, Fig. 3 or 5, on all boilers over 36 in. and on any boiler, regardless of size which is to carry over 100 lb. per square inch. Under 36 in. the lap joint as shown in Figs. 1 and 2 may be used.

The Canadian rules do not prohibit the use of lap joints but restrict their use by penalizing them by increasing the factor of safety. The butt joints allowed by the Canadian rules are shown in Figs. 4 and 6. They do not allow the double-riveted butt joint, as shown in Fig. 3, but require that they shall have both straps of equal width. Fig. 3 is a good kind of joint and well adapted for use on small boilers, while Fig. 4 is more expensive and less efficient, owing to the close spacing of the rivets in the outer row, weakening the shell at this line. Joints, Figs. 5 and 6, are essentially the same except that Fig. 6 has the inner butt-strap scarfed to take the rivets in the circumferential seam. Ohio and Massachusetts do not require this, nor do they object to it.

There should be a rule governing the distance between the rows of rivets, as it is possible to put them so close together that the sum of the two diagonal ligaments between the rivet holes will be less than the ligaments between the two rivet holes in one row. A joint can be made which will figure a higher efficiency than it possesses. The Canadian rules are rather cumbersome and involved, but they do cover this weakness found in the Ohio rules. A rule which requires that the sum of the two diagonal ligaments between the holes in adjacent rows shall be greater than the ligament between two holes in the same row by at least ten per cent. is recommended.

Rivet Holes

The Ohio rules require that nearly all rivet holes shall be drilled full size or punched under size, then drilled or reamed to full size with plates, butt straps and heads bolted up in position.

The Alberta rules prefer rivet holes drilled from solid plates, but permit punching and reaming certain sizes and are more practical in this respect than the Ohio rules when applied to riveted joints of standard construction. For British Columbia all rivet holes must be made perfectly true and fair by clean-cutting punches or drills; the sharp edges and burrs are to be removed by slight counter-sinking and burr reaming.

It is therefore suggested that the rules now in force in Ohio and Massachusetts be modified to read that rivet holes, when punched, shall be 1/4 in. less than full size in plates over 5/8 in. in thickness; 3/16 in. less than full size in plates over 3/8 in. and not exceeding 5/8 in. in thickness; and 1/8 in. less than full size for plates 3/8 in. in thickness and less. If this modification of these rules were allowed it would bring the practical application of the Canadian and States rules to uniformity.

In a case where two sheets of unequal thickness are riveted together in a lap joint, it is recommended that the amount the holes are required to be reamed out shall be determined by the thinner plate. The thicker sheet under the same condition always is stronger than the thinner, and therefore does not require any more reamed out. When the holes which come together are the same size it makes fitting up much easier and does not in any way impair the strength of the joint.

Stayed Surfaces

This subject has been covered quite thoroughly by Mr. MacDonald, but a few other points may be brought out.

TABLE 2. SHOWING COMPARISON OF WORKING PRESSURES ALLOWED ON FLAT SURFACES WHEN SCREWED STAY BOLTS WITH RIVETED ENDS ARE USED

Thickness of Plate	Pitch of Stay Bolts	Area of Surface, Sq.In.	Allowable Working Pressure, Lb. per Sq.In. Ohio and Mass.	Alberta, Ont. & Sask.	British Col.
5/16	4 1/2 x 4 1/2"	20 1/4	170	138	222
5/16	5 x 5"	25	170	161	245
5/16	5 1/2 x 5 1/2"	31.64	170	173	253
5/16	6 1/2 x 6 1/2"	37.51	170	205	270
5/16	6 3/4 x 6 3/4"	45.56	170	213	274
5/16	7 1/4 x 7 1/4"	52.56	170	228	287
5/16	7 1/4 x 7 1/4"	62.02	170	234	290

In this table, 170 lb. per square inch is taken as a working pressure and the pitch as given by the table in the Ohio rules. The allowable pressures for these pitches for others are computed from the formulas given in their rules. It will be noticed that Alberta allows the lowest pressure on the thin plates and is more liberal on thicker plates, etc.

The subject of uneven and irregular spacing of staybolts is one that is of importance on medium and small sizes of boilers. In laying out boilers of this kind it is often impossible to arrange the stays in uniformly spaced rows, consequently some provision should be made for unequal pitches and irregular spacings as is done by the Canadian formula which works out so that whether applied to regular or uneven spacing, the results will be the same, while for irregular spacing the area supported will be slightly less than with regular spacing.

These rules allow the substitution of $\frac{S_h^2 + S_v^2}{2}$ for S^2 when the horizontal and vertical pitches are not alike. S_h and S_v representing the horizontal and vertical spacing of stays. This substitution with uneven spacing results in a reduction of area supported for a given pressure in proportion to the variation between the two spacings.

In case there is a portion of a boiler which does not permit of regular or uneven spacing of staybolts the laws in the Canadian Provinces allow the substitution of

$$\frac{(dS_1 + dS_2)^2}{8} \text{ for } S^2$$

in which dS_1 and dS_2 are the diagonal distances between centers of staybolts.

The Ohio and Massachusetts rules do not provide for irregular spacing, but require that the pressure shall be figured from the greatest pitch.

The difference in the results obtained by the various formulas can best be compared by referring to Plate II. in which the upper figures 1, 2 and 3 represent equal areas with the results as obtained by the various formulas

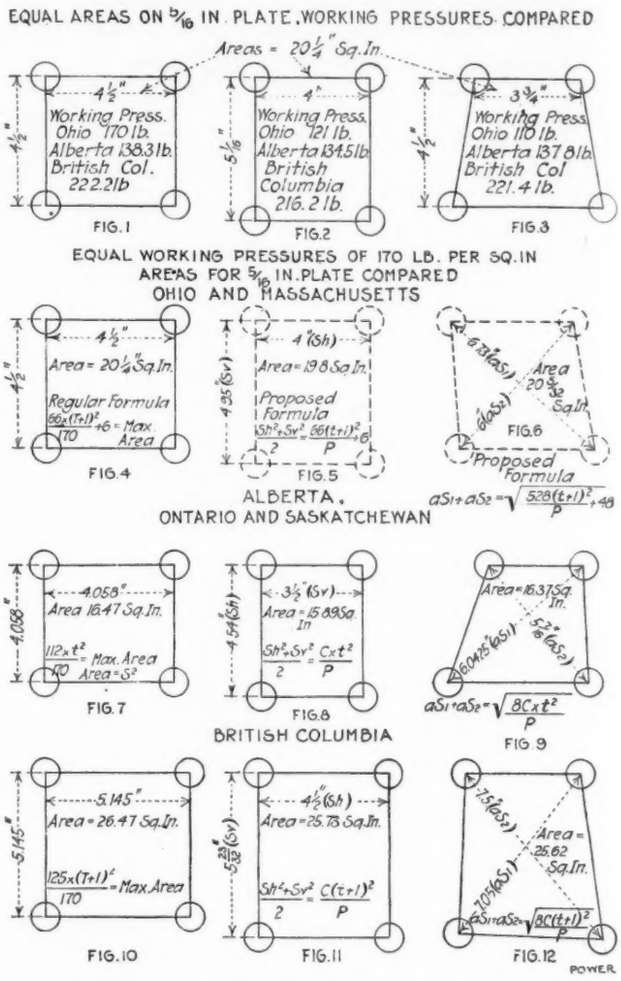


PLATE II. AREAS AND PRESSURES COMPARED*

shown thereon. In Figs. 2 and 3 S, for Ohio must be taken from the greatest distance, which accounts for the low pressures shown thereon. In the lower Figs. 4 to 12, the comparison is made with equal pressures, (170 lb.), the diagrams being each drawn to the same scale and the number of square inches shown thereon, give the comparison of areas as figured by the various rules. Referring to Figs. 5 and 6, Ohio and Massachusetts give no rule for figuring these areas, but we have for Fig. 5 substituted

$$\frac{S_h^2 + S_v^2}{2} \text{ for } S^2$$

in the regular formula $S^2 = \frac{C \times (t+1)^2}{P} + 6$

the same as allowed in the Canadian rules—then the formula for Fig. 5 becomes $\frac{S_h^2 + S_v^2}{2} = \frac{C \times (t+1)^2}{P} + 6$

In actual practice one of these dimensions, either S_h or S_v, will be predetermined so that it is only necessary to solve for the other.

*To agree with the text read dS_1 for aS1, dS_2 for aS2, S_h for Sh and S_v for Sv in this plate.

For Fig. 6, irregular spacing, we have substituted $(dS_1 + dS_2)^2$ for S^2 so the formula for this case becomes

$$dS_1 + dS_2 = \sqrt{\frac{8 \times C \times (t+1)^2}{P}} + 48$$

In practice the sum of the two distances $dS_1 + dS_2$, will usually be used in laying out the staybolts, and it is only necessary to see that the sum of these two distances does not exceed the sum of the diagonals of the square diagram as shown in Fig. 4. If one diagonal is predetermined the other may be calculated easily.

After using the Canadian formulas in laying out several sizes of boilers and making careful comparisons of the pressures allowed by the various rules, it is recommended that these substitutions in place of S^2 for uneven and irregular spacing be allowed in all of the rules.

The distance in inches which the head is considered as supported from the shell and tubes is given in Table 3 for several thicknesses of plate and 170 lb., working pressure.

TABLE 3

Thickness of Plate In.	Distance from Shell: Ohio, Mass. In.	Alberta, Ont., Sask. In.	British Columbia In.	Distance from Outside of Tube: Ohio, Mass. In.	Distance from Center of Tube: Alberta, Ont. Sask. In.	British Columbia In.
7/16	3	2.02	2.57+Rad. at flange	2	2.02	2.57
1/2	3	2.44	3 In.+R "	2	2.44	3
9/16	3	2.84	3.42+R "	2	2.69	3.42
5/8	3	3.24	3.85+R "	2	3.24	3.85
11/16	3	3.65	4.28+R "	2	3.65	4.28
3/4	3	4.06	4.71+R "	2	4.06	4.71
13/16	3	4.46	5.15+R "	2	4.46	5.15

It will be noticed that the distance allowed by Ohio is the same for any thickness of plate and for all pressures. The Canadian formulas take into consideration the thickness of plate and the pressure so the distance changes with these two terms. Notice also that the British Columbia rules allow the addition of the curve at the flange while none of the other rules take this into account. This curve, no doubt, gives support to the head.

The heads, used on locomotive-type boilers are shown in Plate III; Fig. 1, shows the portion of the rear head which is considered supported by the shell according to the several rules while Fig. 2 shows the similar parts of the tube sheet. The inner crescent-shaped part being the area which is to be supported by stays or braces.

The Ohio rules make no mention of doubling plates, but some provision should be made in all the rules for the added strength obtained by their use, as is done in the Alberta rules, where the thickness of plate in the formula is taken as 75 per cent. of the combined thickness of the two plates, when the doubling plate is securely riveted to the head.

Staybolts, Through Stays and Diagonal Braces

The maximum stress per square inch allowed by the various rules is given in the table which follows:

TABLE 4

Kind of Stay and Material	1¼" Dia. and under, Ohio and Mass. Lb.	Over 1¼" Dia., Ohio and Mass. Lb.	Less than 1¼ Sq.In. Net Sect. Area, Alberta, Ont., Sask., Lb.	Over 1¼ Sq.In. Net Sect. Area, Alberta, Ont. and Sask., Lb.	Not Worked in Fire (Any Dia.) B.C. Lb.
*Stay bolts, mild steel, weldless	6500	7000	8000	9000	9000
Stay bolts, wrought iron, weldless	6500	7000	7000	7000	7000
Through stays, steel weldless	8000	9000	8000	9000	9000
Through stays, wrought iron, weldless	7000	7500	7000	7000	7000
Diagonal or crowfoot braces, steel, weldless	7500	8000	8000	9000	9000
Diagonal or crowfoot braces, wrought iron, weldless	6500	7000	7000	7000	7000

*In Ohio and Massachusetts if a certified report of the physical properties of weldless stays or stay bolts is filed with the data report, the maximum allowable stress of such stays may be based on a factor of safety of six and five-tenths (6.5).

In the Canadian provinces the angularity of the diagonal braces must be taken into account when figuring the load on them while in Ohio and Massachusetts there is a reduction made in the maximum stress allowed, which is intended to cover the increase in strain due to this angularity. According to all of the laws under consideration threaded staybolts with riveted ends are approved. For through stays, Ohio and Massachusetts do not specify in the printed rules any regular way of attaching them, but the Board of Boiler Rules in Massachusetts has made the requirement that all through stays shall have nuts on the inside and outside of heads. In the Canadian provinces the through stays must have nuts on the outside and the ends are not allowed to be riveted. If nuts are placed on the inside of the plates a greater constant is allowed in figuring the working pressure on the heads.

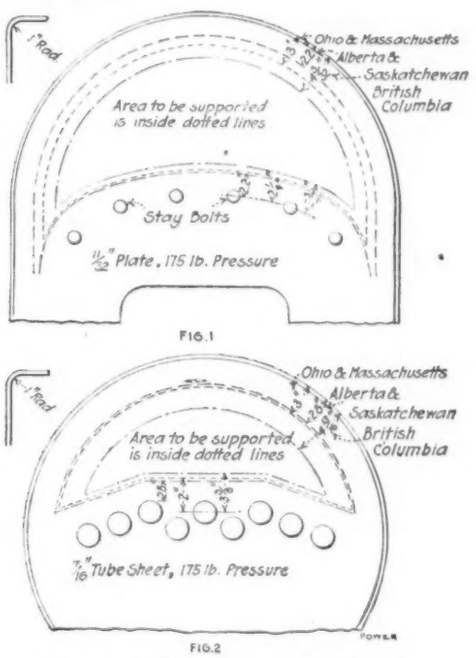


PLATE III. AREA TO BE STAYED

Steel angle and tee bars are not allowed to be used to support the segments of heads on boilers over 36 in. in diameter and carrying a pressure of over 100 lb. per square inch.

Handholes and Other Openings

All of the rules require that in the locomotive type of boiler there shall be at least six handholes located substantially the same.

In addition to the six handholes mentioned the Canadian rules require that there shall be six washout plugs in a boiler or that the total number of handholes and washout plugs combined shall be at least twelve.

The Ohio and Massachusetts rules do not require these washout plugs. It would be, however, advisable on this type of boiler to require a washout hole at or near the waist seam on top of the boiler and another in the front tube sheet above the tubes or in the shell sheet near this tube sheet, omitting the other four required by the Canadian rules.

The Ohio rules require that an opening for a threaded-pipe connection shall not have less than the minimum number of threads, as shown in Table 5.

TABLE 5.

Size of pipe connection in inches	1 and 1¼	1½ and 2	2½ to 4 inc.	4½ to 6 inc.
No. of threads per inch	11½	11½	8	8
Minimum no. of threads required in opening	4	5	7	8
Minimum thickness of material required to give above no. of thds.	0.348″ (0.375″ = 3/8″)	0.435″ (0.4375″ = 7/16″)	0.875″	1″

If the thickness of material in the boiler is not sufficient to give such number of threads, there shall be a standard flange, or steel plate, substantially riveted to the boiler to give the required number of threads.

By the Alberta rules the boiler shall be reinforced with a plate securely riveted to the shell, and threads full size through both plates, and the pipe fitting tightly in both. I consider the rules of Ohio in regard to pipe openings superior since the thickness of the plate determines whether the opening shall be reinforced or not.

Steam Domes on Cylindrical Shell of Boiler

The Ohio rules make but little mention regarding domes on a boiler. but do require that when a dome is to be used, there shall be a working drawing of the same submitted to the department of inspection for approval.

The rules of Massachusetts are, in the opinion of the writer, rather absurd when applied to small boilers in view of the fact that no consideration is taken of the factor of safety which the joints figure or the working pressure which is carried, neither is there any consideration taken of the size of the dome.

The writer commends the method of reinforcing the openings in the shell under the dome as required in the Alberta and Saskatchewan rules.

The single-riveted lap seam should be allowed on the flange of a dome when the tensile strength of the rivets has a factor of safety of not less than ten when calculated from the lifting force of the steam acting on the area inclosed by the rivet circle; and on the vertical seam of the domes, the single-riveted lap joint should be allowed when the inside diameter does not exceed 16 in., providing the factor of safety of said joint shall be at least 8 and the double-riveted lap joint be allowed when the diameter is not over 24 in., providing the factor of safety of said joint shall be at least 7.

Hydrostatic Pressure Test

The hydrostatic pressure test of one and one-half times the working pressure is required to be made on all boilers which are built or inspected under all of the laws which are being considered.

Safety Valves

Spring loaded safety or pop valves, nearly alike, are required by all of the rules, to be connected to every boiler independent of any other steam outlet; no stop valve being allowed in the connection. In Ohio and Massachusetts these valves must have the stem connected directly to the disk of the valve and be provided with a lifting device so the disk can be lifted from the seat with the spindle, while the rules of the Canadian provinces require a pop valve with a lifting gear provided to ease the valve.

Steam Gage

A steam gage and siphon are required on every boiler by all of the rules, and the steam gage shall be attached to the boiler in such a way that the steam cannot be shut off from it except by a stop-cock.

The Ohio rules do not specify the size of water columns to be used, but limit the minimum size of pipe connections to one inch; neither do they require shut-off valves in pipe connections to the boiler. At least three gage-cocks are required on all boilers carrying a pressure of over 25 pounds per square inch.

The Canadian rules require that the internal diameter of the water column shall be 2 and 3 in., respectively, for certain sizes of boilers. Straightway valves or cocks must be placed on the pipes connecting the water column to the boiler and two gage-cocks are required on boilers 30 in. in diameter and under, and three when the diameter exceeds 30 inches.

I consider three gage-cocks are unnecessary on small boilers and the Alberta rule is good in this respect. Putting stop valves in pipe connections to the water column is considered poor practice as these valves may be inadvertently closed and thus be a source of danger. Where these valves have been used they are generally found to be more of an annoyance than a safety device.

From the points that have been mentioned and comparisons that have been made it will be understood to be difficult to manufacture stock boilers that will pass the laws of the various states and provinces.

There is an ever increasing demand for boilers that will be allowed to operate under any of the laws, from purchasers who are doing contract work in various parts of this country as well as in Canada. To meet this demand the manufacturer has often appealed to those in authority for a modification of their rules, but has nearly always found them arbitrary in their decisions and seeming to refuse to approve points of good construction without explaining their objection, simply saying that "the rules do not provide for such construction." For example, Alberta has refused to accept boilers with the double-riveted butt-strap joint, as shown in Plate I, Fig. 3. Likewise, Massachusetts has arbitrarily ruled against other features of good construction, simply because they were not approved by the Board of Boiler Rules.

There will be, no doubt, a great variance of opinions on many of the points covered, but the writer's intention has been to touch on the points of most importance brought to mind in his efforts to design standard boilers manufactured as stock to be shipped into any commonwealth having boiler laws.

Permanent Exhibition Planned by New England Commercial Engineers

The New England Association of Commercial Engineers, with headquarters in Boston, has planned a machinery exchange or bourse in this city, where manufacturers and agents handling power-plant equipment and material may secure space to exhibit and demonstrate their goods.

The association is considering three floors in a large mercantile building midway between North and South stations. The floor area is ample for one hundred spaces, some with private offices, and assembly hall, two smaller halls, lounging room, library, committee and consultation rooms. The aim is to give all the possible advantages of a club, with business possibilities. It is proposed to have the halls used by the many engineering societies, making it the engineering headquarters of New England.

In its circular, the association requests those interested to communicate with Herbert E. Stone, 53 Equitable Building, Boston, Mass.

Wisconsin State Convention

On Sept. 6 and 7, the Wisconsin State Convention was held in Milwaukee, at the Republican House. As it preceded the National convention in the same city, many of the delegates were on hand to attend the big event of the year. John A. Wickert, chairman of the local committee, opened the convention on Sunday afternoon. The address of welcome was given by Henry J. Mistele, and A. Gunderson responded, praising Milwaukee as a convention city and thanking the local committee for its good work. He reviewed the work of the past year and offered some valuable suggestions for the improvement of the organization.

National Secretary Raven spoke of the advantages of getting together and of the improvement in state conventions. He referred to the work being done to secure state license and inspection laws and of money to be appropriated for educational work. The secretary made a special appeal for the careful and judicious selection of officers, as the proper kind of men would set an example to their successors, and by their energy and zeal in office insure the success of the organization they represent.

Fred Ruck, vice-president, responded to the secretary. He enlarged upon the benefits which can be derived from the association, and emphasized the fact that the primary object of the association was to carry on educational work and enact state license and inspection laws. He reviewed efforts in the past which had resulted in failure, but reminded the delegates that plants were getting large and the question asked today was not whether a man could keep the plant running, but what were his accomplishments? At what efficiency could he run the plant? This advancement in requirements by the owner will gradually pave the way for the passage of license and inspection laws, as the owner will realize that the laws will be to his advantage in securing a competent engineer.

The meeting was then turned over to President Gunderson, who favored more advertising for the association. Money should be set aside to defray the expense of traveling and correspondence by the state deputy. All engineers in the state should know of the work the organization is doing. A personal visit will often stir up enthusiasm and result in a new local.

Committees were appointed and routine business followed. The secretary reported a gain in membership of from 520 to 542 (a net gain of 22) during the year. The financial conditions, as reported by the treasurer, were flourishing.

At the second and last session, Monday morning, there was considerable discussion on mileage and missionary work to arouse interest in the association, and increase the enthusiasm of some of the locals already organized.

George H. Wallace, of Racine, pointed out that interest in the home organization was necessary for the success of the local, and indirectly the success of the national body. He outlined methods followed at Racine, which had resulted in an average attendance of 65 per cent. of the membership and 98 per cent. on election nights.

Sheboygan was chosen as the convention city for 1915, and the following officers were elected: Fred Ruck, of Milwaukee, president; Charles Bindrich, of Milwaukee, vice-president; Robert Fenn, of Sheboygan, secretary; John Novotny, of Madison, treasurer; G. H. Wallace, of Racine, conductor; A. C. Willert, of Manitowoc, doorkeeper, and Charles Cahill, of Milwaukee, state deputy.

National Convention N. A. S. E. at Milwaukee

From Sept. 7 to 12 the National Association of Stationary Engineers held its thirty-second annual convention at Milwaukee. The biggest and best, was the unanimous verdict of those attending. The exhibits presented an unusually attractive appearance and were greater in number than ever before. The attendance was good and the entertainment gave evidence of a master hand. Little touches here and there and the unusual at the right moment enhanced an excellent program. The chairman of the local committee, and in fact nearly every member of the N. A. S. E. in Milwaukee, were on the job every minute of the convention. That their work was well done every delegate and visitor will agree, and it is safe to say that Milwaukee will long be remembered as the banner convention city. The Auditorium, with its numerous halls and committee rooms, offered every facility for the convention. The exhibits were displayed in the large amphitheater on the main floor, the business sessions were held in an adjoining hall, the grand ball on the floor above and the field day sports on a track in the basement.

Monday, Sept. 7, was given over to the reception of delegates and visiting engineers. John C. Foote and the convention band were in evidence as they met the various delegations and escorted them to the hotels of the city. Delegates registered and badges were distributed. In the evening the mechanical exposition was officially opened, with John A. Wickert, chairman of the local convention committee, presiding. J. P. Keenan, secretary of the Citizens Business League, welcomed the conventioners to the city and wished them every success. He outlined briefly the great industries of the city and invited the delegates to look them over. Homer Whelpley, president of the National Exhibitors' Association, appreciated the efforts of the local committees and was desirous for a large attendance of local engineers. National Vice-President Ray spoke of the value of the exhibits as an educational feature. A careful study of the various appliances would result in a great deal of good, as the latest and best in power-plant equipment could be seen under one roof. President Coe officially opened the exhibition.

OFFICIAL OPENING

Tuesday morning the convention was officially called to order by John A. Wickert, who briefly referred to the efforts made in bringing the convention to Milwaukee. The present gathering was compared to the conventions of 1888 and 1900 held in Milwaukee. Rev. W. T. Dorward offered the invocation and Gov. F. E. McGovern was introduced. In his address of welcome the governor declared that the invention of James Watt in 1769 had benefited civilization more than the accomplishments of Wellington or Napoleon. Watt's genius and the sagacity of his partners marked the beginning of the end of household manufacture and inaugurated the era of steam, which has been responsible for the tremendous development of the industries. The governor spoke of the efforts of the state to secure compensation to the workmen for industrial accidents. He favored state license and inspection laws and offered to coöperate with the association in bringing the matter before the legislature. President Coe made a suitable response and Mayor Bading welcomed the delegates to the city, pointing out its industries, beautiful parks, recreation features and above all the strong yet well balanced spirit of personal liberty which ruled the city. The mayor believed that the licensing of engineers should be a state function and not that of a city. National Vice-President Ray thanked the state and city executives for their cordial welcome, outlined the objects and ideals of the association and concluded with a fitting tribute to Milwaukee.

W. G. Bruce, secretary of the Merchants and Manufacturers' Association, recounted briefly the historic and civic peculiarities of the city. "Efficiency should be the keynote of the organization" were his parting words. It is this factor which has made Milwaukee one of the largest manufacturing centers and in the shadows of Chicago increased her population from a few scattered settlers to a city of 400,000 in the past eighty years.

Past President McGrath linked the convention city with the names of Reynolds and Hollis and spoke of the wonderful transition caused by steam. The work of the association was bearing fruit, and no better proof was needed than the personnel of the audience.

Chairman Wickert presented President Coe with a silver-banded gavel. The latter assumed the chair and after the appointment of the usual committees the session adjourned for the official photograph.

OFFICIAL REPORTS

The afternoon session was devoted to official reports of the national president, secretary, treasurer and license and educational committees. The president reviewed the work of the past year under the headings: Education, License Legislation, "The National Engineer," State Associations and National Calendar, ending with the following seven recommendations:

"First: That the advisory board in conjunction with the

National educational committee and under the supervision of the president, be allowed to spend a sum not to exceed $2000 for the completion of all slides under way and to present a policy that will demonstrate the true value of such a system, and the other work for the coming year.

Second: That a committee be appointed by the National president to work in conjunction with the local convention committee on a program that will establish a uniform standard of procedure and in this way assist the smaller states to accomplish greater results. Also that a standard badge be adopted for state committees.

Third: That the legislative committee, under the supervision of the National president be allowed a sum not to exceed $2000 for the carrying out of an ambitious policy of license and boiler inspection laws.

Fourth: That an amendment as introduced by No. 1 relating to nonresident members be approved, as this will allow your national officers a greater leeway to increase our membership and revenue.

Fifth: That we do not continue the return dividend to the associations as no indications are apparent that the same has increased our income from our paper, increased the membership or increased the allowance to delegates from the association; and in its place would recommend that $5000 be set aside for propaganda work to be expended in five states selected by the convention or the National president. And for the carrying out of this work a member be selected who has had a broad experience in the details of our organization, and one who will devote all of his time to this and other work as designated by and under the supervision of the National president.

Sixth: That all slides and property of the advisory and educational committees be insured.

Seventh: That the present policy of bonding our funds in bank be continued.

National Deputy and Vice-President Ray reported twelve new associations. Dues to troubles experienced by state deputies with corresponding secretaries of state subordinate associations be recommended a committee of three be appointed to devise a system of keeping suitable records.

Secretary Raven's report was bound in a 24-page booklet covering all details of business transacted, increase of local organizations, list of new associations, etc. The total membership is now 22,118. The report of the National treasurer showed expenditures of nearly $40,000 and a reduction of the treasury balance to $20,000.

The National educational committee gave a full report. Their work followed as closely as possible the suggestions given by last year's committee. In the prize question and answer contest from Jan. 1 to Apr. 1, 44 papers were presented, 25 in the elementary and 19 in the advanced contest. The prizes were awarded as follows:

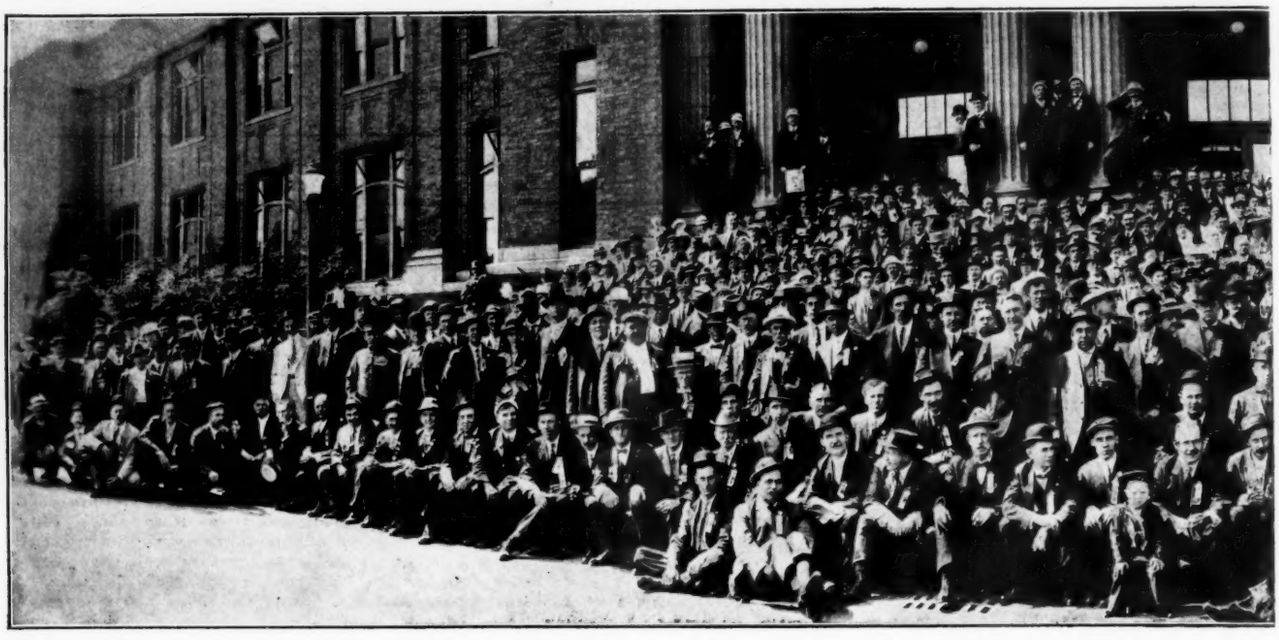
ADVANCED CONTEST

First, $75—Romeo A. Grise, Connecticut, No. 7.
Second, $50—Martin O'Connor, Wisconsin, No. 1.
Third, $30—Joseph Collins, Massachusetts, No. 17.

ELEMENTARY CONTEST

First, $50—John E. Jamboe, Wisconsin, No. 18.
Second, $30—Harry Swindler, Ohio, No. 50.
Third, $10—Robert R. Frey, Ohio, No. 42.

Following last year's plan, the committee again offered four prizes to associations which held the best meetings from an educational standpoint, the conditions being that the secretary should send a synopsis of the lecture or talk, the number taking part in the discussion, percentage of membership present, etc. Seven associations sent in reports of 24 meetings as compared to two associations and three reports last year. Announcement of rewards was reserved for a later date. The information bureau had answered 75 questions during the last year and a great deal of time and money had been spent in getting up sets of lantern slides for educational purposes. Details as to number and character of the slides were given and recommendations were made for a continuation of the work.



DELEGATES AND GUESTS AT THE THIRTY-THIRD NATIONAL

Kentucky and New Jersey were the only states heard from on contemplated legislation. In the former a license bill was defeated and in New Jersey the necessary appropriation for financing the engineers' license department was secured.

Wednesday morning session was given over to routine business, the presentation of other decorations to associations making gains of over 20 and silk flags to those adding more than 10 members. For the former 16 were eligible, Ohio No. 21 leading with a gain of 151. Flags were awarded to 17 associations.

On Thursday the credential committee reported that 411 delegates were in attendance. The mileage was 311,648, and at 5c. a mile would amount to $15,584.40. The trustees of "The National Engineer" reported a total volume of business of $86,470 and a production of revenue for the association of $17,300. A resolution calling on the president to appoint a representative to attend the meeting of the American Society of Mechanical Engineers dealing with the standardization of laws pertaining to the construction and operation of steam boilers was adopted. At the close of the session the annual memorial service was held. During the past year 180 members had passed away.

At the meeting of the Life and Accident Department, James G. Beckerleg, of Chicago, was reëlected chairman of the board of trustees, W. M. Brainerd was elected as a member and J. D. Taylor, of New York City, was reëlected secretary-treasurer at a salary of $1200 per year. The policy holders total about 2200.

On Friday the ways and means committee recommended $2500 for the educational work next year, and $2000 to the license committee for a comprehensive campaign. Both proposals were adopted. The contract for printing "The National Engineer" for a period of five years beginning February, 1915, was reawarded to the Mechanical Press of Chicago.

Officers of the Ladies' Auxiliary were escorted to the platform and welcomed by President Coe. Response was made by President Sophie Whelan. She reported 12 pensioners on the list, each receiving $15 per month. It was her earnest plea that this amount be increased to $20 or even $25 per month. Mrs. Margaret Flynn, secretary, read the financial statement. In September of 1909, the auxiliary had $3975.70, since then $8962.75 had been received and $5589.69 had been paid out. Mrs. Gertrude Hunt, vice-president, gave a brief address and the treasurer, Mrs. Emma M. Stone, told of the great good accomplished by the pension fund. A committee appointed to take up the usual collection for the pension fund received $128.47.

ELECTION RETURNS

Election of officers was the next order of business and resulted as follows:

President, Frederick L. Ray, of Louisville, Ky.; vice-president, Walter H. Damon, of Springfield, Mass.; secretary, Fred W. Raven, of Chicago, Ill.; treasurer, Samuel B. Forse, of Pittsburgh, Penn.; trustee of "The National Engineer" for the term of five years, Henry J. Mistele, of Milwaukee, Wis.; conductor, Louis A. Kroner, of Cleveland, Ohio; doorkeeper, J. J. McDonald, of Tacoma, Wash.

Columbus, Ohio, was chosen as the next convention city.

ENTERTAINMENT

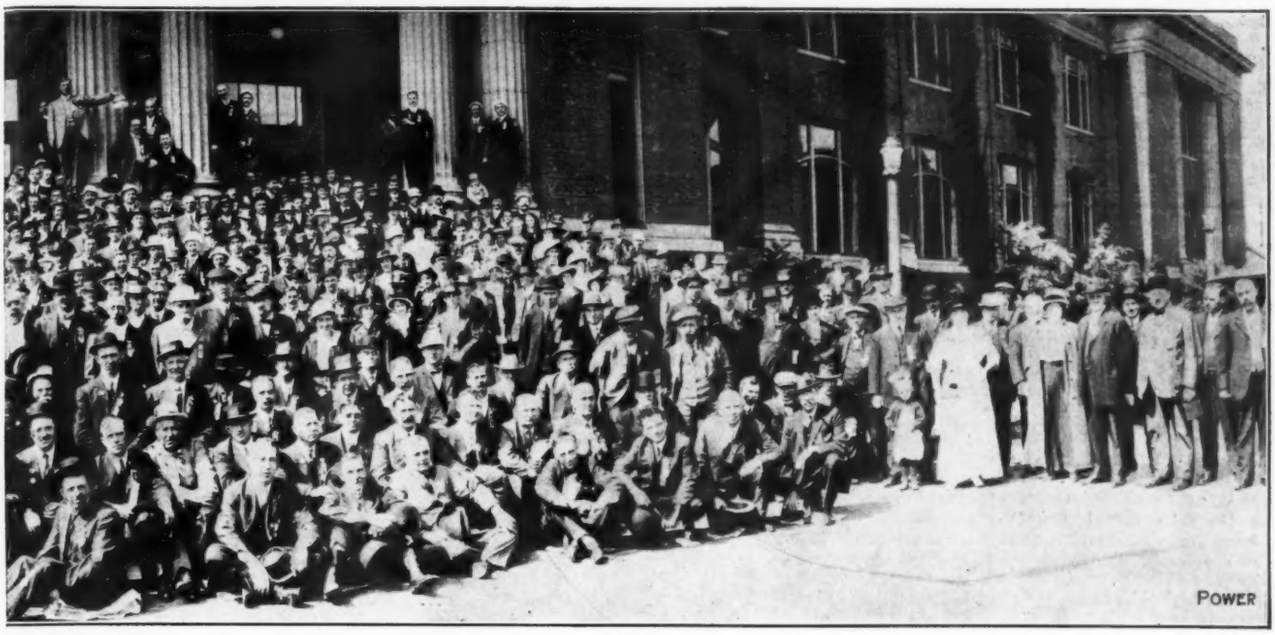
Entertainment features were a visit to the Schlitz Brewing Co., a smoker under the auspices of the exhibitors in Juneau Hall auditorium, a luncheon at Allis-Chalmers Co. and an inspection of the works, band concerts at the exhibition hall, a field day in which all participated, a vaudeville show by the exhibitors, automobile sight-seeing trips and on Friday evening the grand ball and cotillion. This was a grand affair, ably conducted. Over 10,000 favors or souvenirs were given away. A feature was the explosion of a paper boiler resulting in a shower of confetti over the audience. As a prelude the National officers were installed. Dad Beckerleg with the first National president, Henry Cozens, acting as conductor, officiated.

LADIES' AUXILIARY

On Wednesday afternoon the fourteenth annual convention of the National Ladies' Auxiliary convened at the Wisconsin Hotel, with Rose J. Tellier, chairlady of the local convention committee, presiding. Mrs. Teller welcomed the conventioners to Milwaukee and was followed by Rev. W. T. Dorward in an eloquent address. Response was made by Ollie L. Heckler, past National president, who spoke of the work of the organization and referred particularly to the pension fund. The treasurer, Mrs. Emma M. Stone, reported a balance on hand of $7338.76. That evening a card party was held at the auditorium and on Friday the following officers were elected: President, Mrs. Gertrude Hunt; vice-president, Mrs. M. Huntington; corresponding secretary, Mrs. Margaret A. Flynn; treasurer, Mrs. Emma M. Stone; conductor, Mrs. Moore; chaplain, Mrs. Minnie Wickert; doorkeeper, Mrs. Lowrie.

THE EXHIBITS

These were arranged in excellent taste and covered a wide range of power plant apparatus. There were 198 booths, 143 individual firms exhibiting and approximately 500 representatives. The display is credited as being the best in the history of the organization. At the annual meeting of the National Exhibitors' Association the following officers were elected: President, Harry A. Pastre of the Elliot Co., Pittsburgh; vice-president, Lane Thompson of the Lunkenheimer Co., Cincinnati; secretary, H. D. Raymond of the A. W. Chesterton Co., Boston; treasurer, J. W. Peterson of the Richardson-Phenix Co., Milwaukee; executive committee, T. C. Green of the Garlock Packing Co., Pittsburgh; P. T. Payne of the Dearborn Chemical Co., Chicago; Charles Cullen of the William Powell Co., Cincinnati; A. R. Foley of the Home Rubber Co., Trenton, N. J.; and C. A. Wilhoft of the New York Belting & Packing Co., New York City.



CONVENTION OF THE N. A. S. E., AT MILWAUKEE, WIS., SEPT. 7 TO 12, 1914

BOOKS RECEIVED

HEAT ENGINES. By John R. Allen. McGraw-Hill Book Co., New York City. Cloth; 320 pages, 6x9¼ in.; 185 illustrations; tables. Price, $3.

TECHNICAL MECHANICS. By Edward R. Maurer. John Wiley & Sons, Inc., New York. Third edition. Cloth; 356 pages, 6x9½ in.; 91 illustrations. Price, $2.50.

PUMPING BY COMPRESSED AIR. By Edmund M. Ivens. John Wiley & Sons, Inc., New York City. Cloth; 244 pages, 5¾x9¼ in.; 106 illustrations; tables. Price $3.

NEW PUBLICATIONS

FUEL, GASEOUS, LIQUID AND SOLID. By J. H. Coste and E. R. Andrews. Published by J. B. Lippincott Co., Philadelphia, 1914. Size 5x8 in.; 278 pages; illustrated. Price $2

No attempt is made to treat the economic aspect of the various fuels and their uses, as there is abundance of literature upon this subject; instead, the authors have confined their efforts to the production of a reference book of laboratory methods for making analyses and determining the heat values of fuels.

The text is arranged in two parts, the first devoted to the chemical and physical examination of gaseous, liquid and solid fuels, with directions for sampling and analyzing, and the second covers the calorimetry of such fuels. The work of such authorities as the Bureau of Mines, the Amer-

ican Chemical Society, the Royal Society, etc., has been freely quoted, approved apparatus is described, and the opinions of the authors are given as to the methods and appliances likely to yield the most satisfactory results under different conditions.

While not highly technical, in the sense of theoretical and mathematical treatment, the book is not adapted to the amateur, but rather to the needs of one who has had some experience in laboratory methods.

MECHANICS AND HEAT. By William Ballantyne Anderson, Ph.D. McGraw-Hill Book Co., Inc., New York and London. 6x9 in.; 349 pages; cloth; illustrated. Price, $2.

This is not, as might be inferred from the title, a dissertation upon the mechanical or dynamic theory of heat, but a text book made up from the mimeograph notes used by the author in his work as associate professor of physics at the Iowa State College, treating of elementary mechanics and of heat. The author has conducted the recitations as well as having lectured, and this experience has been of value in revising the notes to meet the difficulties of the student as the teacher has known him.

The book is divided into three sections: Mechanics, Properties of Matter, and Heat, comprising in all 18 chapters. Through it all, the practical application of the principles taught has been emphasized, and the numerous sketches assist the student in fixing the relations of the laws to concrete examples. Every principle treated in the text is brought up, so far as possible, in a problem, so that in working all of the problems a review of practically the entire book is obtained. The treatment is not beyond the student with a very elementary knowledge of algebra and trigonometry, and the book would well serve one following a course of self-instruction in its subject.

PERSONALS

Royal C. Wise, sales-engineer, formerly secretary and half-owner of the Western Pump & Engineering Co., has disposed of that interest, and established headquarters in the Madison Terminal Building, 9 South Clinton St., Chicago, where he will handle pumping machinery, compressors, and accessories.

A. H. Whiteside has been appointed vice-president and general sales manager of the Goulds Manufacturing Co., of Seneca Falls, N. Y., manufacturer of hand, triplex and centrifugal pumps. Mr. Whiteside is well known in the machinery and allied trades. During the past fifteen years he has been connected with the Stirling Boiler Co. as southern manager, with the Westinghouse Electric & Manufacturing Co. as its Baltimore representative and with the Allis-Chalmers Co. as manager of its power and electric department. In the latter capacity he had charge of all the pumping engine and centrifugal pump business.

Mr. Whiteside succeeds W. E. Davis, who has been obliged to give up some of his active duties due to injuries sustained several months ago.

ENGINEERING AFFAIRS

Uniform Boiler Regulations—The "Canadian Manufacturer" reports that during the last week in June and the first week in July, representatives from several of the provinces met in the Parliament Buildings, Toronto, to discuss boiler regulations and arrive, if possible, at a uniform design. At the conference were the following chief boiler inspectors: John Peck, British Columbia; R. M. Blackburn, Saskatchewan, and D. Metcalf, Ontario. P. J. Tobin, inspector of public buildings, Quebec, represented Quebec, while Nova Scotia was represented by W. G. Matthewson.

Manufacturers of boilers are very much interested in the outcome, as the adoption of uniform regulations will mean that boilers inspected and passed upon during construction in one province can be put into operation in any part of the dominion without further inspection.

At present the regulations in Alberta, Saskatchewan and Ontario are the same, while there are none in operation in the other provinces, though some of them have inspection regulations under consideration.

Wentworth Institute, in Boston, Mass., is a school for instructing in the mechanic arts, founded by Arioch Wentworth. It was incorporated in 1904 and opened for instruction, September, 1911. Last May a new main building was completed, nearly doubling the floor space, so that the institute will be better than ever equipped to carry out its aim, which is to increase the average standard of skill and intelligence in all of the trades for which it establishes courses. Among the latter are electrical construction and operation, the steam engine and the operation of power plants, applied electricity and electrical machinery. Quoting from the catalog for 1914-15, relative to the power-plant course:

This course is intended primarily for stationary engineers who wish to become more competent, and for young men who are preparing to take examinations for engineers' licenses.

The instruction covers in a thorough and practical way the principles underlying the generation and use of steam, boiler-room practice and engine-room practice.

By means of practical talks and lectures, the student is taught the laws of heat, work, energy and power; the meaning of horsepower and the method of calculating the power developed in an engine cylinder; the action of steam in condensing and non-condensing engines; the characteristics of simple, compound and triple-expansion engines; and the influence of different types of valve gears, etc.

Practice is also given in the laboratory and power plant. This includes setting valves, taking indicator cards, calculating horsepower, making pump tests, injector tests and engine tests for steam consumption and efficiency, etc.; also different methods of boiler firing and conducting boiler tests.

Large Egyptian Pumping Plant—One of the largest pumping installations in the world is being built by the Egyptian Government to drain Lake Mareotis, near Alexandria. It will consist of 18 enormous pumps of the Humphrey type. Each pump is 8 ft. 8 in. in diameter, and is capable of delivering 100,000,000 gal. per day through a lift of 20 ft. The maximum internal diameter of the combustion chamber will be 8 ft. 8 in., and its height 14 ft. The water-valve box will be 8 ft. 8 in. in diameter and 7 ft. high, and it will be fitted with 100 valves of the hinge type, specially designed to enable any valve to close upon an obstruction, without throwing undue strain on the hinges.—"Scientific American."

NEW EQUIPMENT

ATLANTIC COAST STATES

Plans have been prepared for a 200-hp. development in Greensboro Vt., costing $20,000. The plant will supply electricity to the neighboring towns. M. L. Sanders, White River Junction, is Engr.-in-Charge.

The Municipal Gas Co., Albany, N. Y., is having plans prepared by Thomas H. Murray, of the New York Edison Co., Irving Pl. and 15th St., New York, for a two-story power house. Alexander Hamilton is Gen. Mgr.

The Municipal Council, Lewiston, Penn., contemplates establishing a municipal electric-light plant in Lewistown. The estimated cost is $79,000.

SOUTHERN STATES

J. H. Peabody and P. R. Fagan, Cameron, W. Va., have made application for a franchise to build an electric-light plant at Cameron.

The Logan County Light & Power Co., Logan, W. Va., will build a new power station. The following equipment will be required, four 500-hp. boilers, two 2500-kw. turbines, pumps and condensers.

An election will be held Oct. 8 by the citizens of Waterboro, S. C., to vote on the proposition of issuing bonds for $15,000, the proceeds of which will be used for the installation of a municipal electric-light plant.

At an election held Aug. 21, the citizens of Fort Meade, Fla., voted to issue bonds for $25,000 the proceeds of which will be used for the construction of a municipal electric-light plant.

The Beattyville Utilities Co., Beattyville, Ky., is in the market for equipment for a lighting plant. A 150-hp. boiler, 100-hp. engine, 100-kw. generator, a 2300-volt alternator and a switchboard will be required. H. S. Van Zan is Pres.

CENTRAL STATES

Plans are being prepared by Briggs & Melson, 669 Rose Bldg., Cleveland, Ohio, for the construction of a power house at Cleveland, for the Cleveland Seating Co. D. A. Grubb, 550 Rose Bldg., is Mgr.

The Pioneer Pole & Shaft Co., Piqua, Ohio, will purchase motors for the electrification of its plant at Louisville, Ky. Walter Gillette is Supt.

The Public Service Commission has granted permission to the Madison Light & Ry. Co., Madison, Ind., to issue $25,000 in bonds for extending and improving its system. New boilers, and engine and generator and extensions to its local lines are included in the improvements.